The Journal of
THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

Vol. 23 **DECEMBER, 1957** **No. 4**

REGISTERED AT THE GENERAL POST OFFICE SYDNEY FOR TRANSMISSION BY POST AS A PERIODICAL

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Acknowledged in Vol. 23 (1957)—March and June—£1,455 from nineteen (19) organisations.

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CONTENTS

ARTICLES— Page

The past decade in agriculture — and the next, by A. F. Bell .. 279
The role of mathematics in soil physics, by J. R. Philip .. 293
The biological system of plant introduction, by O. H. Frankel .. 302

TECHNICAL PAPERS—

The control of mistletoe by trunk injection, by C. G. Greenham and A. G. Brown 308
Control of Blue Mould (Peronospora tabacina, Adam) in infected tobacco seedlings, by M. Mandryk .. 319
A salinity survey of the Mirrool Irrigation Area, by H. Groenewegen .. 323

TECHNICAL NOTES—

The effect of sod-seeding clovers on the productivity of a paspalum pasture in the Richmond River district of New South Wales, by F. C. Crofts, J. W. McGarity and Hilary V. Rayner .. 329
The effect of irrigated pasture in the rice rotation on seed populations of Echinochloa crus-pavonis, by O. B. Williams .. 331
A method of measuring the evaporation loss from sprinklers, by M. R. Till .. 333
Some fluctuations within rabbit populations in Western Australia, by C. D. Gooding and J. L. Long .. 334
Bullamon lucerne (Psoralea eriantha Benth.)—a plant worth watching, by P. J. Skerman .. 337
A source of error in pot experiments with sulphur, by N. J. Barrow .. 339
Time of harvest in relation to grain-breakage on milling in rice, by E. C. B. Langfield .. 340
A note on alleged cooler summers, by G. W. Leeper .. 342
Weight responses to tick control and phosphate supplementation in beef cattle at Katherine, N.T., by M. J. T. Norman .. 344

THESES .. 346

LETTER TO THE EDITOR .. 349

TALKS .. 353

NEWS ITEMS .. 363

INSTITUTE AFFAIRS—

Personal Notes .. 373
Branch Notes .. 376

BOOK REVIEWS .. 291, 318, 322, 328

BOOK LIST .. 373

THE JOURNAL OF THE AUSTRALIAN INSTITUTE OF AGRICULTURAL SCIENCE

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Contributions are of three types, namely: "Articles", "Technical Papers" and "Technical Notes". For information about the size and form of each type of contribution, see page 2 of the March, 1955, issue of the Journal.

Manuscripts should be double spaced and should be submitted in duplicate, as part of the delay in referring is then avoided.

For more detailed information concerning the preparation and lay-out of scientific papers, authors are referred to the C.S.I.R.O. publication "Guide to Authors" and to an article entitled "The Preparation and Editing of Technical Papers" by N. S. Noble, published in the Australian Library Journal, April, 1954. The policy laid down in these publications is also largely followed by this Journal.

In addition to the contributions described above, the Journal is pleased to publish "Letters", "News Items", "Talks" and "Personal Notes" which have been received from, or which are of interest to, members of the Institute.

Intending subscribers should send annual subscriptions and details of forwarding addresses to the Business Manager.

Published Quarterly. Annual Subscription Rate: Within Australia £1/10/-, *British Countries,* £1/13/-, *Foreign Countries* £1/15/-.

Single Copies 7/6 including postage.

Quotation from this Journal in whole or in part is permissible provided due acknowledgement is made.

ARTICLES

THE PAST DECADE IN AGRICULTURE— AND THE NEXT

By A. F. BELL

In presenting this public address on behalf of the Australian Institute of Agricultural Science I propose to direct my main attention to the subject of plant industry, since this is essentially the sphere of interest of this Institute. I shall, however, necessarily make some reference to the complementary animal industries. I propose, also, to discuss Queensland agriculture in particular and to emphasise the social and applied aspects of agriculture rather than the purely scientific. Finally, in the uncertain role of prophet, peering a decade ahead, I hope I shall be forgiven if the wish appears to father some of the prophecy.

The past decade is essentially the post-war period. It has been a period of great change and of great importance, and history may well record that this was our decade of decision. The changes we have made, and the foundations we have laid, will determine the pattern of our agriculture for many years ahead.

We are presently experiencing the growing pains attendant upon the change from extensive to intensive production. In the past we have followed the pattern of the frontier State with broad acres and emphasis on production per man. We are now passing into the stage when, with increasing pressure for land, we must also promote emphasis on production per acre or per animal.

Our scientific problems in Queensland are accentuated by the fact that the world areas of comparable latitude are populated by coloured races who have not, as yet, developed agricultural science to any considerable extent. We are thrown upon our own scientific resources much more than are the agricultural communities of southern Australia.

The complexity of the problem is further increased by the size of Queensland. It is as big as England, Scotland, Wales, Ireland, Norway, Sweden, Denmark, Netherlands, Belgium, and France. We have one-third of the usable land of Australia; the range of variation in climate is probably as great as for the rest of Australia; and the range of commercial crops is certainly greater than over the rest of Australia.

As a preliminary to discussion of the subject in hand it may be as well to record recent progress as measured by production statistics.

Since 1945/46 the area under crops has increased from 1.8 million acres to 2.6 millions; 2.6 million acres is, however, very little more than one-half of one per cent. of the area of Queensland. Crop production has increased at a much greater rate: Of our major crops, total grain production has doubled; sugar has almost doubled; tobacco has trebled; pineapple, our major fruit, has more than doubled; beef has more than doubled, and wool has increased by 25 per cent.

These increases have been achieved in the face of an actual decline in the number of holdings devoted to crop production. Total milk production has been increased by about 10 per cent., while the number of dairy farms has declined by the same percentage.

A. F. BELL, B.Sc., M.S., D.I.C., is Under-Secretary of the Queensland Department of Agriculture and Stock, Brisbane. *This Address was delivered at a Public Meeting of the Queensland Branch of the Institute in Brisbane on September* 25, 1957.

Obviously our quantity production per acre and production per man in the field are increasing at a good rate. From which it may be deduced that our efficiency as primary producers is increasing similarly.

The Change in Marketing Structure

During the war, and for varying periods afterwards, the United Kingdom Government purchased Australia's exportable surpluses of primary products. These purchases were made in bulk at prices determined from time to time by agreement between the two Governments. The prices were usually considerably below those then ruling on the world's markets.

Post-war efforts were made by Australian producers to carry on these agreements in amended form but the negotiations usually foundered on the rock of prices. Only two price agreements remain, the satisfactory Commonwealth Sugar Agreement and the not-so-satisfactory 15-Year Meat Agreement.

The war and immediate post-war bulk purchase system left two unfavourable legacies: Firstly the United Kingdom's need had been for quantity rather than quality; in the absence of adequate incentive payments the quality of much of Australian produce deteriorated, or at least failed to advance. Secondly Australian exporters lost their experience in sales negotiation and there grew up a generation of producers who did not know the uncertainties and complexities of competitive marketing.

These circumstances, coupled with a recovery in world production and falling world prices, have made the export market difficult. We must re-adjust our attitude to quality and to competition; we must improve techniques; we must establish farming as a business with continuous cost analysis; and above all we must attain greater flexibility in farming so that we can switch quickly from less profitable lines to those which are more profitable for the time being.

Thus we enter an era when primary production calls for even greater and more intensified technical research, assistance, and guidance.

The export market for grain, canned fruit, and dried fruit has tightened but although selling has at times been slow, the exportable surpluses have been sold. Sugar, covered by a long-term agreement negotiated mainly by the sugar industry itself has achieved stability and at present has an export earning capacity of more than £25 millions annually.

Fortunately the market for wool remains relatively stable. Whilst synthetic and vegetable fibres are strong competitors, nevertheless rising world standards of living maintain a good demand for the available wool. It is fortunate that this is so since Australia is over-dependent on wool; last year wool contributed £500 millions to our record export earnings of £1,000 millions.

The export market for other animal produce is less favourable. Dairy produce has been in oversupply on the London market and has suffered in competition with other more favourably situated countries. The United Kingdom egg market has almost disappeared. By virtue of annual subsidies of some £30 millions sterling, the United Kingdom is now producing 95 per cent. of its eggs-in-shell.

For various reasons, including distance from markets, our meat suffers from variable quality and uncertain deliveries. Over the past two years the British Government has made deficiency payments in accordance with its guarantee of average prices under the 15-Year Agreement.

The difficulties of export marketing have been accentuated by the accumulation of vast surpluses of farm produce within the United States. Due to overlong retention of war-time price support schemes the United States has produced far beyond its capacity either to consume or to export with profit. These surpluses are now being sold to various needy countries at bargain prices, and inevitably the result is disadvantageous to young developing countries such as Australia, New Zealand, and South Africa.

So far the various steps taken by the United States Government to curb production seem only to have increased it. The latest proposal is a "soil bank" and its impact on future production will be a matter of concern to us.

The heavily subsidised British agricultural industries have seriously reduced the traditional markets for Australian produce in the United Kingdom. Having been caught seriously short of food in two world wars it appears likely that this support policy will be continued.

The European Common Market, which proposes a more or less free-trade Customs Union for Western European countries and their colonies, is also a potential threat to Australia's export business.

All this adds up to the conclusion that not only must we keep on improving our technical efficiency, but we must develop a much more positive approach to the marketing of our primary produce. In short, we must henceforth *sell* our goods and not just merely produce them for sale.

The marketing organisations of primary producers must study the purchaser's requirements and preferences and see that he gets them. They must advertise; they must seek out new markets; they must insist on graded and quality produce; and they must study the art of packaging.

It might here be interposed that the Queensland Butter Board is doing a good job along these lines in seeking new markets in the East.

Likewise the domestic market needs much more study than it has had in the past. Stability can rarely be attained in any industry unless the domestic market absorbs a high proportion of production. Where exports are large, the home market needs developing to the limit.

This is well exemplified in the dairy industry. Falling export prices, and the threat of margarine, make it essential that the Australian dairy industry reduce its dependence on a "butter economy". This it can do only by finding profitable alternative outlets for butter fat, such as greatly increased sales of cheese, ice-cream, and fresh cream. To achieve this the quality of cheese must be standardised and greatly improved, whilst cream must be presented in the varying strengths and forms which have so increased consumption overseas.

Most people will be surprised to learn that the consumption of fresh cream in Brisbane is about one salt-spoonful per person per day.

Primary industries, as such, are somewhat reluctant to enter upon advertising, and have been content to leave this field to the processors and distributors of primary produce. There seems a need for them to develop a concept of primary and secondary advertising. Primary advertising is concerned with creating increased overall demand for a commodity, be it dairy produce, fruit juices, meat, or stock feeds. Advertising in this field is the legitimate province of the primary producer; after all it is he who is most directly interested in the volume of total sales.

Secondary advertising is competitive advertising in the distribution of a commodity; one processor or distributor claims that his wares are a little better (or perhaps a whole lot better!) than the next. It is true that this form of secondary advertising does in itself help to raise the overall demand, but it should be supplemented by primary advertising by the appropriate producing industry.

Agricultural Science Services

The scientific services available to the primary producer in Queensland have been very considerably expanded during the past decade.

The Commonwealth Scientific and Industrial Research Organisation has established five important research centres —an animal parasitology laboratory at Yeerongpilly; a pasture research institute and a soil science laboratory in the University grounds; a tobacco research station in North Queensland; and a cattle breeding research station at Rockhampton. These centres are rightly concerned more with long-term researches rather than immediate problems.

Over this period the Department of Agriculture and Stock has established twelve more experiment stations devoted to crop and/or animal production, and has decentralised research work by the equipment of twelve more branch laboratories in country centres. Within the Animal Research Institute there has been set up an Animal Husbandry Research Farm at Rocklea and a Bio-

chemical Laboratory at Yeerongpilly. A Wool Technology Laboratory and a Tobacco Research Laboratory have also been added to the laboratories previously established in Brisbane. A Food Technology Laboratory is projected at Hamilton and construction is expected to commence this year.

While satisfactory progress has thus been made in the provision of material facilities this has not been matched by the recruitment or the retention of scientifically-trained personnel. The available butter has been spread very thinly over the bread, and this is particularly true of the Department of Agriculture and Stock.

Excluding overseas students only 32 men have graduated from the Faculty of Agricultural Science within the University of Queensland during the past five years. Of these, eleven have gone into commerce and industry, leaving only 21 to fill vacancies in the teaching services, agricultural research, and agricultural extension.

This average of four graduates a year is a long way from being sufficient even to replace wastage. And that is by no means the last word; a survey now being carried out by the Institute in Queensland indicates that over the past few years the relative intellectual standard of the students attracted to Agriculture has declined in comparison with other Science Faculties. It is a sad state of affairs in a country which in the main earns its living by primary production.

The reasons are not far to seek. The material rewards in the profession of agricultural science are not attractive in competition with other professions, and agriculture inevitably loses out.

From what has been said earlier it is clear that the need for highly-trained agricultural scientists will become progressively greater, not less. This view is well substantiated by the increasing clamour from farmers and farmers' organisations for more and more technical and economic research and guidance. We are in a competitive business and we will be left behind if we do not keep pace with other countries.

We not only want many more graduates in agriculture and allied sciences, we want more facilities for post-graduate study. As buildings grow higher we can no longer afford to ascend them step by step but must use an elevator. As the store of scientific knowledge grows in quantity and complexity so must men be progressively more highly trained before they enter the various professions. For specialised work, be it plant breeding, virus research, or any other avenue, the graduate in Agricultural Science now requires at least some post-graduate training.

Australia suffers from isolation; there is not the concentration of scientists to provide mutual stimulation as there is in Europe, for example. It is therefore essential that selected men be sent overseas at intervals to see what other people are doing. In this respect we have fared very well; since the war 37 officers of the Department of Agriculture and Stock have made 48 visits overseas. You may be interested to know that in the case of 43 of these 48 visits the money for the fares and expenses has come from sources other than State revenue; this we feel is a tangible expression of appreciation from outside. In the majority of cases the Department has met the salaries of these officers during their study tours.

An important facet of the developing agricultural science services has been the employment of scientificaly-trained personnel by the distributors of agricultural chemicals. The activities of these trained consultants have rationalised and stimulated the growth of this increasingly important industry.

Progress of Science and Practice

Let us now turn to consideration of some of the achievements which have stemmed and will stem from the harnessing of science with practice. Naturally, time (and patience) will not permit a full catalogue and I will record but a few examples quite briefly, and then treat two important examples at rather more length.

Science is universal and every advanced country makes its contribution to the common stock of knowledge. But after

the basic discovery has been made, in one country or another, a great deal of further research and experimentation is necessary before treatments or processes are adapted to local conditions. The speed with which new discoveries are applied in a country is dependent upon the number and calibre of scientifically-trained personnel in that country.

The control of insect pests has been completely revolutionised by the post-war insecticides. The sugar industry, for example, saves a half a million pounds a year through the control of one pest. But the insects are still in the fight and one by one they are building up resistance to this or that insecticide. Constant vigilance and constant research are therefore necessary if we are to maintain our advantage. And vigilance and research, be it remembered, need trained men and money.

Weed control has been placed on a new basis by the discovery and application of selective hormone weedicides. These are used mainly for control of broad-leafed weeds. Further great economic advance would come from the discovery of weedicides which are selective within the grass family and which would, for instance, control summer grass in a maize crop with a spray which kills the summer grass without harming the maize. This type of weedicide, and economic killers of nut grass and Johnston grass, are fit subjects for further research.

One of the important developments which has followed local research is the destruction of brigalow scrub by spraying with very small amounts of hormones from aeroplanes.

The understanding of the role of minor elements in the soil is destined to have a tremendous influence on production. There are a number of minerals, essential to plant growth but required in amazingly small quantities. Whiptail, a striking malformation of cauliflowers, is corrected by the addition of only three-quarters of a pound of molybdenum sulphate to the acre.

Current research is demonstrating increasingly large areas of so-called waste land which can be brought into production by adding a little copper, or zinc, or boron, or molybdenum to the soil in addition to the usual fertilizers.

In the coastal strip running north from Brisbane there are some millions of acres commonly called wallum country. These are soils of low fertility but enjoy a good rainfall, are handy to centres of population, are well served by transport and other public services, and are easy to clear. At present they are wastelands but some day, after a lot more soil and plant research, they will be a food bowl for the then great metropolis of Brisbane.

Coonalpyn Downs in South Australia and Wongan Hills in Western Australia bear witness that this is not idle speculation.

Seed certification is an important post-war development. The seed or cuttings are produced from crops which have been planted and grown in isolation under Departmental supervision. The planting material is thus guaranteed to be true to label and free from inherent diseases. It is, in fact, pedigreed seed. The demand has out-stripped the capacity to supply. Most of the grain crops are now planted from certified seed and the scheme has been extended to horticultural planting material such as tomato seed, strawberry runners, pineapple suckers, and citrus budwood. A crop grown from such pedigreed planting material will produce uniform grain or fruit and so raise yield and marketing standards. The time is fast approaching when all major crops, at least, will be produced from certified planting material. The time is also approaching when individual plant industries should operate their own seed certification societies. Once methods have been developed and results demonstrated by Departments of Agriculture or other institutions, then industry should accept responsibility for the maintenance of quality standards.

Few phases of agricultural science can produce so valuable a return, from so little outlay, as plant breeding. We have suffered severely from the lack of advanced training available in genetics in Australian Universities, and facilities are still far below the desirable level. Nevertheless a great deal has been done: About three quarters of the grain crop

is produced from new varieties, or new strains of old varieties, bred in Queensland. More than 80 per cent. of the sugar crop is produced from locally-bred varieties. Cotton and peanuts register 100 per cent. Horticultural crops are increasingly depending on local varieties.

The locally-produced variety has the great advantage that it is selected under the conditions of climate, soil, disease and pest complex, harvesting, and marketing requirements of the area in which it is to be grown. Its chances of dovetailing into local requirements are therefore obviously much greater than the imported variety. There is a great need for expansion of plant-breeding activities and this especially applies to the pasture field. Little has been attempted here, and virtually nothing has been done in the important direction of breeding and selecting from our native grasses. The State badly needs at least half a dozen more plant breeders.

Soil conservation is another post-war development. As a result of a lot of field work, methods of soil conservation suitable to Queensland conditions have been developed on the basis supplied by American research. It is estimated that about 800,000 acres of agricultural land requires protection in some form or other; at present the area needing treatment is growing at a rate about four times as great as the area being protected. In the majority of cases the form of protection needed is only common sense land use, including judicious use of pasture. Whilst there is a great need for increased technical staff there is an equal need for positive personal action, and a changed attitude towards balanced farming, on the part of landholders.

The Moisture Story

Australia is the driest of the Continents. Although having a similar area it has only two-thirds the rainfall of Europe but, being much nearer the equator, evaporation is higher and the need for moisture is greater. The quantity of water flowing down the river Danube is greater than all the stream flow of all the rivers of Australia.

Not only is the rainfall low but it is unusually capricious; the coefficient of variability is greatest in Australia and hence droughts are more frequent.

All this can be said equally of most of Queensland. Whilst it is true that we have a rainfall higher than the Australian average we also have temperatures and evaporation above average. Moreover the summer rainfall characteristic of Queensland is heavy and wasteful, and the rainy season is more pronounced and restricted in length.

We have, in Queensland, an abundance of most of the factors which favour plant growth—vast areas of fertile soil, flat topography, abundant sunlight, and temperatures favourable to growth throughout the year. We lack only moisture.

The study of soil moisture is therefore of the greatest importance to Queensland and it must receive the close attention of the present and future generations of scientists.

Our farming forebears came from Western Europe, where rain is gentle and regular, and where the agricultural problem is to get rid of excess moisture. Naturally they brought to Australia their traditional farming practices of turning *over* the soil, harrowing to fine smooth tilth, and the frequent cultivation of row-cultivated crops.

Actually the Australian problem is the reverse of this; our task, in most seasons, is to get as much moisture as possible into the soil—and to keep it there. What we want is tine rather than mould-board tillage; leaving the soil with a rough absorbent surface during the rainy season; and the reduction of inter-row cultivation to a minimum.

It is only in very recent years that we have really begun to discard the European system and evolve our own.

Work carried out at the Biloela Regional Experiment Station over the past 30 years, and later on the Darling Downs, has given us a good insight into soil moisture storage and the water requirements of crops.

Working with wheat and grain sorghum (as examples of typical winter and summer crops respectively) it has been ascertained that five or six bushels of

grain per acre can be produced from each available inch of water in the soil. It does not matter much whether this water is already stored in the soil before planting or whether it is absorbed into the soil during the growth of the crop.

You will understand of course that I am talking about an inch of absorbed water—not an inch of rain. It normally takes a great deal more than an inch of rain to get an inch of water into the soil. And, of course, it is only the water in the top three feet or so of soil which is available to these crops. In our good agricultural soils it usually requires about six inches of soil to hold one inch of available water.

Now let us consider what this means in practice in the case of wheat on the Darling Downs. A roughly cultivated field is left fallow through the summer rainy season and absorbs a proportion of the rain. After a heavy rainy season, such as we had last year, the soil may hold water to capacity to a depth of several feet; following a dry year such as this one the water content may be far below capacity.

After the rainy season ends the fields are kept free of weeds by very shallow cultivation which does not dry out the soil. Then, following the first winter rains, the seed bed is prepared and the wheat is planted. Very soon the roots penetrate far enough down to draw on the stored moisture. If this is considerable the crop needs very little more rain to produce a satisfactory yield, although, naturally, freshening spring rains are very acceptable.

On the Biloela Station we have produced over 40 bushels of wheat per acre with less than two inches of rain between germination of the wheat and its harvest. Our average wheat crop in Queensland is about 20 bushels per acre—the highest average in Australia. It is safe to say that in an average season more than 12 of these bushels are produced from water which was in the soil before planting.

The story is much the same for the summer crops such as sorghum when grown in lower rainfall areas. In this case however rough fallowing during the summer rainy season means that the land must then remain unplanted until the following late spring or early summer. This in turn means that a plot of ground would yield only one crop in two years.

Although there is, of course, plenty of land where the summer rain is sufficient in quantity and distribution to grow a good summer crop every year, this is not the case in areas with lower rainfall and shorter rainy season. It was the non-acceptance of this fact which was one of the contributing causes of the failure of the Queensland-British Food Corporation's sorghum growing venture in the Central Highlands.

I have dealt with this summer fallow-moisture storage question at some length because the principles are of transcendental importance to our future development.

There is a great deal of Queensland, including much of the beef country and most of the sheep country, which is not farming land in the accepted sense. The rainfall in most years is too low, and the growing season too short, to produce reasonable forage crops or to carry grain crops to maturity. They would be less than half grown before the rain and soil moisture petered out.

However you will readily see that with summer fallow and biennial cropping there opens up a stupendous possibility of producing forage crops and ensilage.

Whilst this practice may not become widespread until the pressure for land becomes greater, it has already started among imaginative landholders. Once adopted it would minimise or eliminate catastrophic drought losses and would stabilise production through the year. It could entirely alter the pattern of our pastoral industries.

And while on the subject of water, perhaps I should mention "water harvesting". This consists in a farmer throwing a bank across a stream or billabong on his farm and catching and storing storm run-off instead of letting it flow away; it is only the rooftop and household tank on a large scale. Water harvesting has been publicised by Messrs. H. J. Geddes and P. A. Yeomans on their New South Wales properties but the biggest single

scheme is on the Atherton Tableland of North Queensland.

The impounded water, harvested on the farm, is used for irrigation. Naturally water harvesting cannot be practised on a perfectly flat farm, or on a farm with very broken terrain. However there seems little doubt that where conditions are suitable it can and will be developed in the future.

There are two directions in which research can help. In Queensland the minimum evaporation from a free water surface is four feet a year; it is much greater inland. The top four feet of a shallow dam represents a big proportion of the water and it would be a great achievement if this evaporation could be prevented. Industrial chemists have already achieved results by the use of cetyl alcohol but there is still a long way to go.

The second problem is the elimination of loss by seepage. The development of a cheap impervious plastic which could be used to line dams and channels, or a cheap chemical to "pug" the soil, could greatly increase the water available for irrigation.

The Pasture Story

Grass is the most important crop in Australia—and the most neglected. This is particularly true of Queensland. The sheep and beef cattle industries are almost entirely based on pasture grass, while dairy cattle are grass fed to almost the same degree. These animal industries are the mainstay of our National and State economy.

On dairy farms it has been the practice to sow an introduced grass—such as Rhodes grass or paspalum—immediately after the felling and burning of scrub. But largely the process rested there; top dressing, renovation, or systematic subdivision were largely unknown; native grasses have gradually invaded a large proportion of the sown areas.

In the beef cattle industry pasture improvement has heretofore been restricted to ring-barking to relieve the native grasses from shade and the competition of the trees for soil moisture. In sheep country the native grasses have been largely left to look after themselves.

These remarks are to be construed primarily as statement of fact—not as criticism of landholders. The farmer and the pastoralist are in their businesses to make a living and that has usually been hard enough in all conscience. (We must not judge the long-term financial rewards of primary producers by the conditions of the post-war years.)

When land is cheap, and pressure for land is not great, the most profitable and indeed the reasonable policy for primary producers is to have broad acres, and concentrate upon output per man and not output per unit area. It is only when values rise, and pressure for land increases, that change of emphasis becomes necessary.

This is the phase upon which we have now entered—the change from extensive methods of production to intensive methods. We have only just started along the track; we have a long way to go.

In current jargon the economic climate was not favourable to the promulgation of the pasture doctrine until the higher values of the post-war period began to assert themselves.

At the end of the war the Department of Agriculture and Stock had, I think, but one man engaged upon agrostology. At present we have, directly and indirectly, the equivalent of at least 50 men engaged on pasture work. And in the meantime C.S.I.R.O. has multiplied its pasture team several times.

As an example of the indirect association with pasture development it is interesting to quote that of the 1603 samples analysed in the Analytical Section of the Agricultural Chemical Laboratory during the year 1956/57, no less than 1195 samples were grasses and fodders.

The native grasses of Queensland have, down the ages, adapted themselves to the temperature and rainfall distribution. They are characterised by flush growth during the short hot wet season but this is followed by their rapid drying and loss of nutritive value during the late autumn, winter, and spring. It is the loss of both nutritive value and palatability which is responsible for the pattern of growth of

our beef cattle, the seasonal rise and decline of dairy production, and so on.

This pattern as applied to beef cattle is a fairly rapid gain in weight for the four months of late summer and autumn; then follows a loss of weight for the next four months, and then during the next four months a slow gain of weight to regain the late autumn position. In other words there is a net growing period of only about four months.

Dairy production follows a generally similar pattern, with late summer production being more than twice as great as winter production.

The objectives of pasture improvement are to raise the nutritional level of the pastures; to extend the growing season; to reduce the loss of nutritive value when the grass dies; to produce a pasture which would justify conservation as hay or silage; and to lift the palatability of both fresh and conserved pasture.

Only by such means can we hope to reduce the seasonal fluctuation in growth and production rates, control quality, and maintain a steady and reliable flow of animal produce to the domestic and world markets.

Achievement is complicated by the fact that most of the native legumes of Queensland, and indeed of the tropics generally, are not good pasture species under relatively dry conditions. A legume is a very desirable component of a pasture; it draws its own nitrogen from the air and shares it with the grasses. Part of our problem is to introduce or develop suitable legumes for incorporation in our pastures.

The past decade has been largely occupied in experimenting with as many species of grass and legume as have been available. The plant introduction section of C.S.I.R.O. has combed foreign countries with similar climates, and has imported hundreds of new species for trial. A great deal has been learned of pasture mixtures and pasture management; much valuable research has been carried out on the nitrogen fixing bacteria associated with pasture legumes; the increased growth rates of grazing stock have been measured; and, finally, pasture improvement has been "sold" to increasing numbers of farmers and graziers.

About 200 pasture experiments are carried out each year, innumerable field days and lectures have been organised, and the Royal National Association's pasture competition has helped greatly to stimulate and sustain interest.

There is, of course, a tremendous amount of work still to be done. We have only scratched the surface of introduction and testing, grazing management, top dressing with major and minor minerals, irrigation, and so on. We can expect handsome dividends from pasture research not only in the next decade but for decades to come.

However, we should not be appalled at the prospect of what waits to be done, but rather should we push on with the research job, while at the same time we make full use of what we have done.

An interesting experiment is now in progress at "Brian Pastures", a cattle husbandry research station near Gayndah. Here the land has been broken up and three introduced grasses (buffel, Rhodes, and green panic), plus legume, are being tested against native pasture—mainly spear grass.

The experiment has been in progress for 28 months and during that period the cattle have made the following weight gains per acre:—

Buffel	306 lb.
Green panic	280 lb.
Rhodes	261 lb.
Native	69 lb.

In other words the improved pastures have produced four times the weight of beef produced by the native pastures. This serves to give some idea of the potential for increased production by the use of improved pastures. And what is more, the beef from the improved pastures has graded better at the meatworks.

I have mentioned buffel grass. This is a grass which is destined to become of great importance in beef production over a large area of Queensland. It is claimed to have been introduced into Australia a good many years ago as packing in the camel saddles imported by the Afghan cameleers. Whether this be strictly true or not I cannot guarantee. Certain it is,

however, buffel grass entered the country without passport or visa. It is becoming a good Australian and, in the process of test and selection, some very useful types are being developed.

No climate is uniform throughout the year and consequently pasture growth is uneven. We cannot stock on the basis of the maximum rate of growth or stock would suffer in the winter. Equally it is uneconomic to stock at the rate of minimum seasonal production and let pasture go to waste. In Queensland, however, we generally stock only at the rate which can be supported in a bad season and so waste fantastic quantities of pasture in all but the bad years.

Obviously we must follow, and we are starting to follow, the rational practice of conserving the excess growth in the flush season and holding it against the season of poor growth or drought.

It has been shown, and is beginning to be accepted, that grass is not merely something to be taken for granted; something for nothing, taken as it comes. It is a crop, our most important crop, and must be tended and grown as a crop. Reserves must be conserved so that a reasonably constant nutritional level may be maintained throughout the year.

No sane person would give his children one-half or one-third rations for a considerable part of the year and expect them to grow and behave normally. We are now realising that this is not good for animals—and that it can be avoided.

Farm Mechanisation

In no phase of primary production has change been more profound or significant than in the mechanisation of farming operations. Both the causes and the effects have been and will continue to be of great social and economic significance.

The mechanisation of farming operations developed very slowly until long after the advent of the tractor. The term "tractor" was indeed an unfortunate choice and for a long time hindered rather than promoted farm mechanisation. The name connoted hauling, and implied that the tractor was a substitute for the horse or the ox. And for many years that is just what it was, a mechanical horse drawing simple old-fashioned implements. Only since the war has it been fully appreciated that the so-called tractor is, in fact, a mobile power unit on which may be fitted an infinite array of directly-operated, specialised tools.

It is high time we discarded the name "tractor"—and with it that dreadful word so beloved of farm machinery firms, the word "tractorisation".

The post-war period has been an era of full employment and in countries with high living standards it has seen the advent of the "welfare" state. Men are not forced to tramp the countryside looking for work. The result has been a rapid dwindling of the supply of casual and itinerant labour in rural areas. The farmer can no longer rely upon seasonal labour for planting, chipping, and harvesting; or upon casual labour for odd jobs.

Farmers' families are smaller and the children are no longer content to remain under the parental roof as a compliant and cheap labour force. The ready employment, high wages, short hours and the varied pleasures of the towns and cities are strong magnets.

In these circumstances the only alternative is mechanisation. A small skilled labour force, with suitable power units and appropriate implements for each job, can carry out all the operations on a large farm. Moreover, each operation can be carried out expediously, and so at the proper time. Skilled work is essentially permanent work and so we see the passing of the farm labourer and his replacement with an artisan.

There are now available implements to clear land, break it up, and perform the operations of planting, cultivation, weed control, pest control, and harvesting, for nearly all field crops. There are mechanical levellers and ditchers for irrigation; scoops, loaders, unloaders, and cranes; post-hole diggers and portable power saws; silo fillers and unloaders. All these are operated by the power unit we have called a "tractor".

Much of this development has taken place since the war; it does not represent the culmination of mechanisation but rather a preview of things to come. Up

to the present the construction of particular farm machines and implements has grown largely from the native genius of farmers. The inventive farmer, with his own hands and at his own expense, builds a contraption which does a particular job. At this stage it is taken over by mechanical engineers and converted into a durable machine.

Until very recently there has been little scientific research into the functions (as distinct from the construction) of farm machinery. The industrial chemist requires to know the manner of each phase and step in a complex chemical reaction. Similarly engineers cannot design the near-perfect machine or implement until they have analysed and integrated each operation. Research of this type has now been initiated in Australia, and, as it grows, must influence profoundly the construction and efficacy of the farm machinery of the future.

The replacement of labour by machines obviously requires a greatly increased capital investment in the farm. The machines cannot, like casual and seasonal labour, be paid off when they are not working; interest, redemption, and depreciation costs continue every day of the year. There is a minimum economic usage for any machine or implement and the farmer must keep them operating above this level. The extent to which he achieves this will determine the profitability of his farming.

The farm of the future must become a larger farm, either by the acquisition of more land or by the intensive cultivation of a greater proportion of the land on existing large holdings. The capital investment will continue to increase and the organisation and management will become more complex.

In short, farming is becoming more a business, and less a personal way of life.

This trend is already pronounced in the United States. Excluding week-end, hobby, and "tax deduction" farms, there are about 4½ million farms in the United States, but 90 per cent. of the production comes from less than 2 million of these. The average farm is now 40 per cent. larger than it was 20 years ago; since the small farms tend to get smaller it seems likely that the fully-productive farm has considerably more than doubled in size over that period.

Another important social question associated with increasing farm mechanisation is the steadily decreasing proportion of the population classified by the Statistician as being "engaged in rural pursuits"; contemplation of this downward trend casts a great gloom upon some people.

Every morning in the United States there are 7,000 new mouths around the national breakfast table; and every morning there are 1,000 less farm workers on the national payroll.

An operator with an appropriate power unit and implements does not liquidate the drivers of six horse teams; he displaces them *on the farm.* Power units, machines, and implements must be manufactured, distributed, and serviced; spare and replacement parts must be manufactured, distributed, and fitted; liquid fuel and oil must be won from the earth, refined, and distributed. The man in the service station, or on the farm machinery assembly line, or in transport service, may be just as much an agricultural worker as the man on the farm.

I suggest that our best yardstick is not the number of people working on a given area of farmland, but the volume of crop and animal produce being yielded by that land.

Finally, increasing mechanisation is raising the production of food and fibre for human consumption by reducing the need to grow fodder for draught and saddle animals. It has been estimated that full mechanisation thereby increases food and fibre production for humans by about 15 per cent. The number of tractors in use in Queensland has trebled in the period under review and farm horse traction is now of minor consequence.

Farm Management or Farm Economics

Heretofore the advisory services provided by Departments of Agriculture, and the like, have been restricted to tendering what is commonly called "technical" advice. That is to say, advice on the biological and mechanical aspects of farming.

There is a growing realisation that the primary producer needs, and is entitled to expect, more than this. Although considerable capital is involved he is running a small unit business; he cannot employ trained executives; he is more often than not his own manager, technician, and one of the operatives.

There is no reason why he should be less in need of advice on management problems than he is in need of advice on technical problems. Indeed, quite the reverse; there are far more institutions ready to give him technical training than to give him farm management training.

This question has received a good deal of attention in the post-war period, particularly in the United States. Indeed it is probable that the great advances recently made in farming in that country are due in considerable measure to the development of farm management advisory services.

It is true that sound advice on farm management requires the prior investigation of at least the more pressing technical problems; good management cannot be superimposed on faulty technical practices. However it is clear that we have now reached the stage of technical knowledge which justifies the establishment of a service for the investigation of the economics of various farm practices and the subsequent advice on farm management.

The Assistant Director of Marketing in the Department of Agriculture and Stock has just returned from the United States, where he has been studying the structure and functions of the farm economics and farm management advisory services. It is proposed to lay the foundations of such a service here. The value of technical processes will be measured in economic terms and overall farm advisory services will thereby become more precise —and less evangelical.

There is no dearth of things to determine or do:

What really are the economics of feeding skim milk to pigs?

When does it cease to be economic to ratoon sugar cane?

What maximum cost of irrigation water can be borne in the irrigation of pasture, or of potatoes, in a given locality?

What proportion of costs should be allocated to equipment, or to buildings, on a dairy farm?

And so we might go on, and on. Most people have an opinion, and perhaps a firm opinion on these questions, but how few really know?

The conservative farmer will not freely accept or act upon management advisory services; he will hold that such advice could only come from the so-called "practical" man. In my experience, the conservative farmer said that very thing about technical advice about thirty years ago. But he slowly changed with the times and now freely accepts technical advice from young scientists; he now appreciates that they are not advising out of their own limited personal experience but from the accumulated knowledge and experience of many people. And he will eventually adopt the same attitude towards advice on farm management.

The Future in Tabloid Form

Assembling and condensing the thoughts which have been expressed it would appear that we can expect the development of the following broad trends in the next decade:

Farms will generally become larger and produce a wider range of animal and plant crops. (Sugar farms will be a notable exception to the latter for special reasons.)

Progressive mechanisation of farm operations will continue, with the farm labour force growing smaller, more skilled, and more highly paid.

Farm power will move away from the jack-of-all-trades tractor in favour of separate tractors for primary and secondary tillage.

Tined implements will largely replace sodturning implements.

There will be a rapidly multiplying increase in use of improved pastures and in fodder conservation.

Cultivation of fodder crops, in association with animal production, will move inland.

The use of fertilizers for field crops will increase greatly.

Water harvesting will develop slowly at first but exploitation of farm underground water supplies will progress rapidly. Dairy farmers will increasingly develop an "insurance patch" of irrigated pasture.

Weed control will be increasingly effected by the spray plant.

Crop plants will be almost entirely grown from certified or pedigreed seed or cuttings of locally-bred varieties.

Beef cattle will carry a growing proportion of *Bos indicus* or "Indian" blood.

Herd recording will gradually become the basis for dairy herd management.

With the increasing importance of the market milk trade there will be a breed shift towards cows producing a greater volume of milk with lower fat content.

Producers' marketing organisations will adopt more positive selling programmes and will be forced to enter the advertising field.

Price structures will include quality incentives.

There may be some better realisation of the tremendous potential in many fields, for coordination and cooperation between individual primary industries.

Farm management advisory services will become established and freely accepted.

There will be some recasting and extension of the technical and scientific training available to farmers and professional agriculturists.

The community will realise that a country in Australia's position cannot afford to allow agricultural science to remain the Cinderella of the professions.

And now, having put my neck well out, let me retract it and finish on a firm confident note of prophecy: A decade from now primary producers will still be dissatisfied with the weather!

(*Received for publication, October* 14, 1957.)

BOOK REVIEWS

INVESTIGATIONS OF VIRUS DISEASES OF BRASSICA CROPS

By L. BROADBENT

(*Cambridge University Press*, 1957, *pp.* VII + 87, 15/- *sterling.*)

This publication of the Agricultural Research Council of Britain has set a standard which might well be emulated by others who, like Dr. Broadbent, have had the opportunity to conduct intensive investigations of virus diseases affecting important crop species. It includes the results of the author's research, reviews the work of other investigators of brassica viruses, and provides a clear and detailed description of the principal viruses, cauliflower mosaic and cabbage black ring spot, and the factors which influence infection with these viruses.

Undoubtedly the most important feature is the detailed study which has been made of the field behaviour of the aphid vectors. Too often, in the past, the mechanism of virus spread in the field has been based on assumption rather than experiment. The author's experiments, which follow a similar pattern to those previously described in his work with potatoes, leave nothing to chance. They clearly demonstrate that disease incidence is related to the abundance and type of aphids, the proximity to other brassica crops, and the degree of infection which has occurred in the seedbed. Winged aphids are shown to be the principal disseminators of virus, and cereal barrier crops a potent factor in hindering their movement and reducing infection of seed-beds.

The work described in this book should be of direct practical value in most countries where brassica crops are grown, and the techniques used for determining the behaviour of vector insects in their natural environment should focus attention on the necessity for more work in this extremely important and much neglected field.

L. L. STUBBS.

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THE ROLE OF MATHEMATICS IN SOIL PHYSICS

By J. R. PHILIP

Miss Susan: *What is algebra exactly: is it those three-cornered things?*

Phoebe: *It is* x *minus* y *equals* z *plus* y *and things like that. And all the time you are saying they are equal, you feel in your heart, why should they be?"*

J. M. Barrie, *Quality Street.*

Summary

Mathematics performs a dual rôle of language and logic, and in a concentrated form which makes possible manipulations which would be otherwise unmanageable. Mathematical operations can be applied to the phenomena of the "real" world only by means of the process of abstraction. This involves conserving in the problem only those factors which have a bearing on the answer we seek, and then identifying these factors with appropriate entities which are amenable to mathematical treatment. Obviously, successful use of mathematics in science requires insight into the phenomenon as well as mathematical competence.

Experiment and observation are the sole primary sources of information about the real world. But, to make effective use of his observations, the scientist must generalize from them. Mathematics provides very powerful means of generalizing primary experimentally determined relationships. In addition, it enables rigorous exploration of the consequences of hypotheses, and can often tell us what are the significant measurements to make in our experiments.

The various applications of mathematics in soil physics are reviewed briefly. The fields discussed are water movement in saturated soils, water movement in unsaturated soils, heat flow, simultaneous heat and moisture transfer, gaseous diffusion, and leaching.

Introduction

The tale is told of a certain Chinese emperor who could not be convinced by mathematical reasoning that the volume of a sphere varies as the cube of its radius. He assented to this doctrine only after he had various size spheres made, filled with water and weighed. Here, I am addressing myself mainly to the people who tend to view mathematical processes with the same suspicion as did the Chinese emperor. Very little of what I say will be new or original to people familiar with the workings of mathematics and its application to the "real" world.

It is too much to expect people not familiar with these matters to appreciate the part mathematics can play in a particular science. This is why the present paper sets out to say much more about mathematics than about soil physics. Shortage of space and time limit special reference to soil physics to little more than an annotated bibliography, which will serve, at least, as raw material for the reader who wishes to pursue the soil physical aspects further.

We limit the compass of the present paper further by omitting from our attention that branch of mathematics called statistics, which would have involved us in issues not strictly relevant to the theme to be pursued here.

The Phenomenon, Mathematics and Abstraction

What I have to say on the rôle of mathematics in scientific research presupposes that what we are aiming at in research is *understanding the phenomenon*, not just in the sense of being wise after the event, but in the sense of understanding observed phenomenon A in such a way that we can *predict* (with some accuracy) the course of some phenomenon

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B related to, but not identical with, A. It is, for our present purposes, beside the point whether we believe that our aim in striving to understand Nature is to gain practical mastery over her, or our interest is in pure knowledge for its own sake. Whatever our motive for wishing to understand the phenomenon, mathematics can play an important part in gaining us our ends.

Mathematics as Language

One often finds in the literature expositions of the relationship between mathematics and science as a whole, which say essentially that mathematics is the language of, or is a language useful to, science. Sir Harold Jeffreys (Jeffreys and Jeffreys 1956) states: "The use of mathematics in science is that of a language, in which we can state relations too complicated to be described, except at inordinate length, in ordinary language." Many distinguished scientists including Leibniz and Williard Gibbs, have put forward this view of mathematics as a language of superior clarity and consistency.

To the person unfriendly to mathematics, this may appear to imply that mathematics is merely a shorthand: that, given enough time and paper, equivalent results would be derived purely verbally.*

Mathematics as Logic

This assumes too passive a picture of the mathematical process. The word "consistency", used above, serves as a clue to its additional properties, though it does not adequately express them. Whatever stating that a language is consistent may mean, it is certainly no guarantee that all statements made in the language are consistent. A man may speak immaculate French and yet make a complete ass of himself, not through any lack in his linguistics, but in his logic.

Mathematics provides a logically rigorous deductive system. In one sense, it is a distillation of the logical operations carried out by all previous mathematicians. For example, Newton and Leibniz, the great minds of the seventeenth century, could take only the first few faltering steps in using the differential and integral calculus, and then only by the utmost concentration of their logical powers; today we make use of the calculus almost automatically. This is due not to any virtue in us, but to this process whereby mathematics can consolidate its gains* by concentrating preceding results so that they become automatically available in the consideration of other (and often more complicated) problems. In this mathematics is more than just a shortcut, because, at least for the more difficult problems, it would probably be beyond the competence of one man to solve the whole problem from scratch (i.e., proceeding verbally and without prior knowledge of the available mathematical apparatus).

Clearly mathematics performs a dual rôle of language *plus* logic, and in a concentrated form which makes possible manipulations which would be otherwise unmanageable.

Abstraction and Mathematics

Like logic, mathematics can operate quite happily in a vacuum, but it is of more interest to most of us if it has some relevance to the real systems which are, properly, the true subjects of our researches. The resources of mathematics *are* available to us, but only under certain conditions. To invoke this genie we need rub no lamp, but we must be pre-

*It may also be objected that mathematics can be of no help in the non-quantitative sciences. Some people (e.g., Arrow 1951) would retort that this is simply not true, since a growing body of pure mathematics deals with qualitative relationships between entities. Yet it must be admitted that the most obvious triumphs of applied mathematics and almost all its present-day usefulness lie in the quantitative sciences. Here we shall have in mind mainly those fields of science which are quantitative, or which would clearly benefit from becoming quantitative.

*This cumulative element is, of course, present to some degree in all science.

pared to *make abstractions*. (It is, of course, true that, whether we are involved in mathematics or not, the generalizations inherent in the manageable, economical view of nature exemplified in a scientific law or theory must rely on the process of abstraction.)

Most of the time we use language without being conscious of the gulf of abstraction between the realities we intend to embody in our sentences and the abstract entities which are all they can ever really be.* Nevertheless, when we pause to consider this gulf, we may thereafter use language with greater care, but we certainly do not abandon the use of language and return to the grunts and gestures of the cavemen.

An entirely analogous gulf exists between observable phenomena and the mathematical relationships we may develop about these phenomena. In this case, too, great circumspection must attend the process of abstraction, but the fact of the need for abstraction is no cause for despair or for turning our backs on the powerful tools which mathematics can offer us to assist our understanding of the phenomenon.

It remains for us to explain what is meant by abstraction. In my experience, many people, including some scientists, are by no means clear as to what abstraction is, and, especially, just how the process of abstraction links the phenomenon to the mathematical process. It, therefore, seems important to dwell on this at some length.

A memorable example of mathematical abstraction is instanced by Alfred North Whitehead (1926). He points out that we think of the number five as applying to appropriate groups of any entities whatsoever—to five fishes, five children, five apples, five days. He goes on: "Thus in considering the relations of the number 'five' to the number 'three', we are thinking of two groups of things, one with five members and the other with three members. But we are entirely abstracting from any consideration of any particular entities, or even of any particular sorts of entities, which go to make up the membership of either of the two groups. We are merely thinking of those relationships between those two groups which are entirely independent of the individual essences of any of the members of any group. This is a very remarkable feat of abstraction; and it must have taken ages for the human race to rise to it. During a long period, groups of fishes will have been compared to each other in respect to their multiplicity, and groups of days to each other. But the first man who noticed the analogy between a group of seven fishes and a group of seven days made a notable advance in the history of thought."

This same discovery has to be made by the developing child, though, no doubt, the child is assisted by the hints of his elders. Thus my three-year-old can, with a great agony of concentration, work out that three two-handed people have six hands between them. If you then point out that the people each have two eyes also, and ask him how many eyes they have between them, the processes of computation start from scratch all over again and, with just as much effort as for the hand problem, he finally deduces the answer six. On the other hand, his five-year-old brother has developed to the stage where he can separate the numbers from the phenomena. Once he has got the answer six to the hand problem he has it immediately available as answer to the eye problem as well. The five-year-old is capable of making the abstraction, and is therefore able to deal efficiently with (what are to the three-year-old) diverse phenomena by the process of generalization. We return to generalization a little later.

The process of abstraction is essentially to strip the phenomenon bare of its ex-

*The recently fashionable science of semantics is no more, really, than an expression of the sudden awareness of some people that words are not all they had been thought to be. See Chase (1947) for a persuasive and readable exposition of semantics.

traneous elements: to conserve in the problem only those factors which have a bearing on the answer we seek. These elements must then be identified with appropriate entities which are amenable to mathematical processes.

Obviously a successful abstraction requires two kinds of skill or insight. Firstly, the person making the abstraction must have sufficient insight into, and empirical knowledge of, the phenomenon to sort out the significant determinants of the system. He must not neglect important factors and, yet, on the other hand, he must not retain in the problem factors which serve only to make matters complicated and obscure but shed no light on the major issues.

Secondly, he must be able to set up his abstract problem in such a way that either the existing apparatus of mathematics can treat it or else he must be prepared to develop specific mathematical methods to deal with the problem.

It is obvious that the successful application of mathematics in scientific research requires a reasonable working knowledge both of the particular field of science and of mathematics. Both the high-powered mathematician without a feeling for the problems of a particular field and the person steeped in the empirical lore of the field but with only a superficial grasp of the methods of mathematics are likely to come to grief.

Research, Generalization and Mathematics

It remains for us to consider ways in which a scientific field makes use of mathematics. Perhaps the most notable is that the possibilities of *generalization* in such a field are greatly strengthened.

An example may make this clear. Let us suppose that, by making tests on suitably insulated cylindrical specimens of a range of substances, we discover that, under steady conditions, the heat flow through the specimen per unit time q, is directly proportional to the difference between the temperatures, T_1, T_2, of the ends, directly proportional to the cross-sectional area of the cylinder, A, and inversely proportional to the distance between the ned faces, L. We may write this

$$q \propto A(T_1—T_2)/L$$

We also notice that the factor of proportionality between the two sides of this relationship is constant for a given material. We may then rewrite it as the equation

$$q = KA(T_1—T_2)/L \qquad (A)$$

where K is a characteristic of the material (the thermal conductivity).

In addition, we find by use of a calorimeter that the amount of heat necessary to raise a mass of any one of our test materials from temperature T_3 to temperature T_4, h, is proportional to the volume of the body, V, and also to the difference in temperature. We may write this

$$h \propto V(T_4—T_3)$$

Let us imagine that we also notice that the factor of proportionality between the two sides of this relationship is constant for a given material. We may then rewrite it as the equation

$$h = CV(T_4—T_3) \qquad (B)$$

where C is also a characteristic of the material (the volumetric heat capacity).

The relationships (A) and (B) are based on only a finite number of values of A, T_1, T_2, L, etc., so they constitute generalizations, but they are generalizations at the level of interpolation based on the assumption of the uniformity of nature. Although the mathematical generalization we shall now consider depends on the same assumption (and no other), it represents generalization on an entirely different level.

Consider a body of any shape whatever, made of a material characterized by given values of K and C, with any initial temperature distribution and subject to any imposed temperature regime (free to vary in time) at its boundaries. Then applying the relationships (A) and (B) and the principle of continuity (simply that the amount of heat flowing into any volume of the body in any time interval

equals the heat flowing out plus the total heat gained by the volume) to any infinitesimal volume element of this body, we arrive at the partial differential equation:—

$$C \frac{\partial T}{\partial t} = K \triangle^2 T \qquad (C)$$

Here T denotes temperature and t time.

Powerful mathematical methods are available for getting the solution of (C) which corresponds to any particular shape of the body, any particular initial temperature distribution within the body and any particular thermal regime (which may vary in time) imposed at its external boundaries. Thus (C) may be said to contain within it the description of all conceivable phenomena in the conduction of heat in a body.* This is always on the understanding that (i) the abstractions (A) and (B) parallel to sufficient accuracy the results of our actual experiments; (ii) our mathematical apparatus is sufficient to deduce from (C) the particular solution of interest to us. Subject to these provisos, we have here a quite extraordinary economy and efficiency of description of nature: and so the science of conduction of heat can be (virtually) crystallized into a single equation.

It would be a salutary exercise to count the man-years and millions of pounds necessary to establish by experiment unaided by mathematics the results implicit in one medium-sized book built around equation (C) (Carslaw and Jaeger 1947).† I should hate to have to wade through the descriptive treatise on the conduction of heat which would replace Carslaw and Jaeger in a world without mathematics.

Our example has dealt with a means of generalizing primary experimental results, the generalization in this case enabling the thermal behaviour of any body to be predicted, once the thermal conductivity and volumetric heat capacity of its substance are known. Equally, we may have set up (A) and (B) as working hypotheses (and, as such, they would have been the simple, obvious ones to make). In this case the mathematical processes leading to (C) and its infinitude of particular solutions would have corresponded, not to a generalization of primary experimental results, but to *a rigorous exploration of the consequences of the hypotheses.* Instead of merely having the hypotheses in the special form (A) plus (B), we can find by our mathematical operations the consequences of the hypotheses under any imaginable set of conditions—for any special shape of body, for any initial temperature distribution, and so forth. Through this mathematical generalization of our hypotheses, we may test these, not only in their raw, primary form (which may be inconvenient to realize in practice), but in any particular form we choose.

Perhaps surprisingly, much research sometimes thought to be "fundamental" is really just an investigation of such effects of different imposed spatial and temporal relationships. Mathematics can render unnecessary a great deal of this experimental hackwork of a science, or at least enable it to be carried out more economically.

There are other aspects to this deductive use of mathematics, which we shall be able to mention only briefly on this occasion. Firstly, the mathematically deducible consequences of the primary (experimental or hypothetical) relationship may not be obvious, and, to quote one authority, "can be extremely unobvious". In this way unsuspected links of causality may be discovered.

*Strictly, in a homogeneous body devoid of sources or sinks of heat. Extension to more complicated cases is straightforward enough, but need not concern us here.

†Poincaré (1913) states: "Experiment is the sole source of truth. It alone can teach us anything new; it alone can give us certainty". But he goes on to add: "We must use our observations, and to do that we must generalize. . . . The scientist must set in order. Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house."

Secondly, mathematical analysis of a phenomenon (or group of phenomena) can reveal to us what parameters of the system determine the phenomenon, and can thus tell us what are the significant measurements to make in our experiments, and, for that matter, what are the significant experiments to perform. This is one of the functions of mathematics Professor Albert Betz had in mind in his talk on scientific research reported recently in *Nature* (Weyl 1957).

Mathematics is, clearly, most useful in unifying a field of science—in discerning relationships within the field and assisting in the process of generalization. It is not necessarily as helpful in the case of a particular *ad hoc* problem. Here it may well be that, unless some previous data are relevant, the immediate answer will be found most efficiently by direct experimental measurement. However, this measurement remains one of Poincaré's isolated "facts" until it is integrated into the body of scientific knowledge.

Soil Physics

The desirable balance between observation and theory (experiment and mathematics) is by no means always maintained in any sector of science. Some fields are plagued with ingenious swarms of mathematicians, much of whose elegant work may be largely vitiated by lack of reference to the real phenomenon (i.e., the abstract entities supposed to represent the phenomenon do so inadequately). Other fields are almost exclusively the preserve of experimentalists and observers; experiments proceed without the benefit of any directing hypothesis, and mountains of unanalyzed (and largely unanalyzable) data accumulate. In whichever direction the out of balance lies, the result is an inefficient and intellectually unwholesome branch of science.

Soil physics has tended to err in the latter rather than the former way, but, in comparison with certain fields, its errors are small indeed. An appreciation of the part mathematics can play in soil physics does seem to be developing. Here we shall discuss very briefly some of the fields in which mathematics has been applied, and, in a few cases, directions in which further mathematical work promises to be useful.

Water Movement in Saturated Soils

The first group of problems to receive extensive mathematical treatment was that concerning steady water movement in saturated homogeneous isotropic (and, later, anistropic) soils. In such cases, the application of Darcy's law leads to potential problems entirely analogous to those arising in the "potential theory" of classical physics. Solutions were thus immediately available. However, in general, these solutions were for boundary conditions of only limited interest to soil physicists and much original work in exploring appropriate solutions of Laplace's equation has been done. Noteworthy in this field has been the work of Childs and colleagues in England (Childs 1943, 1945a, 1945b, 1946, 1947, 1952; Childs and O'Donnell 1951; Edwards 1956) and of Kirkham and colleagues in America (e.g., Kirkham 1945, 1949, 1950a, 1950b, 1951; Kirkham and van Bavel 1948; Luthin and Kirkham 1949; Luthin and Gaskell 1950; Swartzendruber and Kirkham (1956a, 1956b). Others who have contributed include van Deemter (1950), Wedernikov (1936, 1939) and Gustafsson (1946). Studies arising in the petroleum industry (cf. Muskat 1937) have also been of relevance.

A related but distinct field of problems arises in connection with the validity of Darcy's law and the physical nature of permeability. Philip (1957b) has examined the effect of Darcy's law of non-steady conditions of applied potential, but the need remains to extend this to unsaturated systems. The relationship of the permeability of a medium to its geometry seems amenable to analysis by the methods of classical hydrodynamics; work to date on this problem has been reported by Philip (1957g; see also Philip 1957f).

Water Movement in Unsaturated Soils

Many soil-water problems of practical importance in agriculture and hydrology arise in unsaturated soils. Infiltration, the drainage and retention of water in the soil profile, the extraction of soil-water by plants, and the evaporation of water from the soil are all instances of phenomena of this type. Until recently, each of these phenomena had received separate and empirical study, and the possibility of developing a unified body of physical theory connecting them all was not generally recognized. As early as 1931 Richards had developed, in one form, the general partial differential equation describing all these phenomena, though not in the concentration-dependent diffusion form which is proving amenable to analysis. By 1936 Childs had suggested a diffusion form of equation with constant diffusivity. This had the advantage of mathematical tractability, but did not predict details of the phenomena successfully (Kirkham and Feng 1949). In 1948, Childs and Collis-George proposed the description of unsaturated water movement as a concentration-dependent diffusion phenomenon. It remained for Klute (1951) to express the equation in appropriate general form. Solution of this equation required the use of numerical methods* of dealing with concentration-dependent diffusion. Klute applied a method due to Crank and Henry (1949) to the case of horizontal absorption. Subsequently Philip (1955a) devised a more rapid and accurate method of treating this case, and of obtaining solutions of the more complicated vertical case with gravitational effects included, i.e., infiltration (Philip 1957a). Results of analysis by these methods have enabled a comprehensive treatment of infiltration phenomena (Philip 1954, 1957c, 1957d). It has also been found possible to treat the extraction of soil water by plants (Philip 1957c), evaporation from soils (Philip 1954, 1956, 1957c, 1957e), and water retention and drainage in soils (Staple and Lehane 1954; Day and Luthin 1956; Philip 1957c) in terms of this unified approach. It has been found that the vapour phase contribution to (isothermal) soil water movement can be included in this formulation without complicating the mathematics (Philip 1955b). Much further work along these lines remains possible.

This unification of the approach to soil-water problems seems quite a good example of the way in which mathematics can help the discovery of generalizations in a field of science. In this case generalization became feasible only when the appropriate mathematical tools had been devised.

Heat Flow in Soils

One of the oldest mathematical results in soil physics concerns the "soil temperature wave" predicted on the assumptions that the thermal properties of the soil are constant in time and space and that a sinusoidal soil surface temperature is imposed on the system. For many purposes this simple model is useful, but an adequate theory of microclimate requires more exact treatment. A contribution towards an improved theory was made by Lettau (1954). Van Duin (1954) and de Vries and de Wit (1954) have studied the problem of heat flow in layered soils. It is possible that an adequate treatment will need to consider the simultaneous heat and moisture fields in the soil.

*The power of mathematics to deal with real phenomena has been much increased in recent years by advances in techniques of numerical analysis. This is a development quite separate from (but, in some ways, related to) the use of electronic computers. The computers are of great help in solving complicated problems, especially repetitive groups of similar problems. The term "electronic brain" is, of course, a misnomer. These machines can be no more subtle than the men who design them and write their programmes (though here again the cumulative property we have noticed in mathematics as a whole operates, and may make possible solutions not previously within our competence). As Professor T. M. Cherry remarked at Dunedin, "They are like Casabianca—excessively obedient, and deficient in initiative."

Another interesting set of problems concerns the relationship between the composition of the soil (soil minerals, water, air) and its thermal properties. De Vries (1952a, b) has provided a comprehensive mathematical analysis of these problems.

Simultaneous Moisture and Heat Transfer in Soils

Many problems of evaporation from soils, especially soils with dry surfaces, require the distribution of both moisture and heat to be taken into account. Philip and de Vries (1957) have given a general theory of the interaction between heat and moisture in the soil which reveals why previous explanations of thermal moisture transfer in terms of vapour diffusion have failed. The theory has been used to obtain some solutions of the problem of evaporation from bare soil, which, although simplified, explain experimental results reasonably well (Philip 1956, 1957e; de Vries 1957).

Gaseous Diffusion in Soils

A further group of soil physical problems deals with the transfer of the products of respiration within the soil to the atmosphere. The problem is, in general, to determine the composition of the soil air under given conditions of air content, rate of respiration and geometry. Established mathematical techniques in potential theory can probably take the analysis of this type of problem somewhat further than has been done to date. Most of the published mathematical work in this field is due to van Bavel (1951, 1952, 1954). The relationship between air content and apparent gaseous diffusion coefficient has been studied mathematically by de Vries (1950, 1952a).

Leaching

Salt transfer in the soil is another phenomenon of importance in soil physics. The subject is at present in a very active state. Recent contributions by Scheidegger (1955), van der Molen (1956), Day (1956), Rifai, Kaufman and Todd (1956), and Gardner and Brooks (1957), all make use of mathematical physical theories of leaching.

Other Problems

The preceding list of mathematical applications in soil physics makes no claims to be exhaustive. There are certainly other fields which might be mentioned—for example, the applications of neutron transport theory to the calibration of slow neutron moisture meters (Holmes 1956).

Acknowledgments

My colleagues at the Regional Pastoral Laboratory, Deniliquin (Dr. D. A. de Vries, in particular) have been most helpful in offering criticisms of this paper in its various stages, and I should like to thank them.

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These references include two books by Sawyer (1943, 1955) and one by Sutton (1954), which are pleasantly written, popular books, giving a good picture of the methods and apparatus of mathematics*. Sutton's book, in particular, sets out the viewpoint of the applied mathematician. It is from this book, by the way, that the quotation which heads this paper was lifted.

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(*Received for publication, September* 27, 1957.)

THE BIOLOGICAL SYSTEM OF PLANT INTRODUCTION

By O. H. FRANKEL

Migration and Introduction

Plant migration is as old as agriculture itself. It has played an important part in the evolution of cultivated plants. As Darlington (1956) points out, Vavilov himself allotted many of the ancient seed crops to a multiplicity of centres of origin. A multiplicity of habitats would tend to raise evolutionary opportunities.

This process is by no means at an end, and recent human migration—accompanied and followed by plant migration—has provided vast new areas for the evolutionary development of old and new crops. Much might be learned from these introductions of old plants into the New World and vice versa were it not that in so many instances historical and biological data are scant indeed. Many of the migrants came without the will of man, both useful plants and weeds; only in relatively few instances are reasonably accurate case histories extant or deducible (Frankel 1954).

It may be a humbling thought that where our pre-scientific ancestors' introductions so strikingly succeeded, or where chance or involuntary introductions established themselves over wide areas, as did so many Mediterranean plants in Australia, our own deliberate efforts on the whole seem relatively meagre. My reaction is two-fold. Firstly, for every success we know there must have been countless failures. Secondly, involuntary introductions, or one might say invasions, are often on a "broad front" whereas our scientific endeavours are all too frequently restricted to narrow experimental conditions. We may have a good deal to learn from such comparisons.

The subject of this paper is not plant migration but plant introduction, conducted deliberately in our time with the aid of the scientific and technical resources at our disposal. It concentrates, perhaps a little unduly, on the scientific, and in particular the biological, aspects of plant introduction. This does not mean that the more empirical approaches do not deserve our close attention or that they do not warrant application. The pragmatic approach still pays dividends. There is a place for a range of methods, from the empirical "trying out" of new plants on farm or experiment station, to a full biological analysis. Yet, it is desirable that the bases of plant introduction should be surveyed, appreciated and investigated.

Australia is especially concerned with plant introduction.* At the advent of European colonisers the continent was devoid of an economic flora which would satisfy the needs and aspirations of civilized man. Every plant used in any of the more intensive types of land use has come from beyond the sea. The only plants Australia has herself contributed to the rest of the world are *Eucalyptus* spp., *Casuarina* spp., *Macadamia tirnifolia*, the Australian nut, which has been improved in Hawaii; and there is a possibility of some Australian plants supplying materials for chemical and pharmaceutical industries.

*For a brief description of aims and organization of plant introduction in Australia one may refer to Hartley (1954a) and to the Annual Reports of the Division of Plant Industry, C.S.I.R.O.

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Phases of Plant Introduction

Plant introduction becomes a complex process once the machinery of modern science gets hold of it. The components of the process are outlined in Table I.

TABLE I.
The structure of scientific plant introduction.

Phases	Disciplines
Definition of purpose	Agronomy and ecology Plant parasitology Genetics and plant breeding Animal nutrition Technology etc.
Location, identification and classification	Plant geography Taxonomy
Acquisition	Exchange Collecting
Inspection Quarantine	Parasitology Seed technology
Examination and exploitation	Agronomy Parasitology Genetics and plant breeding Physiology Biochemistry Human nutrition Animal nutrition Technology etc.

In effect we have transformed the simple operation of shifting a plant or a seed from one place to another into an elaborate structure, with intricate scientific and technological disciplines impinging upon processes which previously were governed by chance or by empirical judgment. Whether this is a change for the better will depend upon the nature of the available information and on the manner of its application. The discussion which follows stresses the biological elements of the system rather than the technical and administrative aspects of plant introduction, but the relevance of the former for the latter becomes abundantly apparent.

Definition of Objectives

Discoveries are rarely made unless they are anticipated; we do not often find what we are not looking for. Hence the clearer the conception of the objective, the more likely are we to find the required character or characters. Such a definition in the first instance will be at the ecological or technological levels—resistance to diseases or injuries, improvement of quality, extension of grazing period into summer or winter, etc, etc. Yet such definitions, simple though they sound, may present great difficulties. For example, a scientific definition of quality characteristics in some of our common cereals is as yet lacking; the introduction of new pasture plants is severely handicapped by the wide gaps in our knowledge of the heredity/environment interactions in some of our most ancient and common ones—not to name the great intrinsic difficulty of attaining an understanding of the effect of the grazing animal on the plant. Winter dormancy in white clover is a desirable character in Sweden, a highly undesirable one in New Zealand (Whyte *et al.* 1953). In Southern Australia the extension of the grazing period by even a few weeks into the dry summer would be of great importance, as would be improved winter production; but an increase in the production during the main growing season would only add to the waste of excess feed. These objectives sound reasonably specific; yet when a series of defoliations is superimposed on genetic, edaphic and seasonal variation, definition of the type or types of desirable plants presents intrinsic difficulties. Here comparative and experimental biology must come to our assistance.

The Genetic System of Plant Introduction

Shorn of the non-essentials plant introduction is the transposition of a genetic entity from an environment to which it is attuned to one in which it is untried. The smaller the genetic entity in relation to the organism as a whole and the less important it is to the life functions, or alternatively the more alike the two environments, the easier and the more suc-

cessful the transposition is likely to be. Hence, transfer of a single, or of a few resistance genes, of a simple morphological character like awns or their absence, in fact small chromosome segments with a gene content of relatively slight physiological significance constitute a minor problem in plant introduction. Major adjustments to established plants grade up in difficulty to the introduction of altogether new plants. The whole series is outlined in Table II.

TABLE II.

Genetic and physiological classification of genes and plant introductions.

Genetic Change	Physiological Change	Examples of Objectives
One or few genes	Simple and relatively superficial morphological or physiological characters	Resistance to diseases or pests, flower colours, awns or their absence
One or few genes or gene blocks	Specific morphological or physiological characters of greater significance in ontogeny	Tillering habits, frost resistance, flowering habit, grain quality
Several gene blocks or full complement	General adaptation	Yield increase, extension of habitat. New introductions

Where genes or gene blocks are to be transferred from an introduced to an established plant, the task is one of genetic incorporation, and of physiological adjustment of the hybrid. Where an altogether new plant is to be introduced, it may, and in most instances will, benefit from genetic adjustment to the new environment. All too often this phase is neglected, and a new crop plant is judged by its performance at the original, i.e., unadjusted level of adaptation. It is an intrinsic difficulty in plant introduction that a final judgment cannot be made without adaptation—costly in time and resources, hence shunned without distinctive *a priori* promise.

A new crop plant should be introduced with the maximum range of variation adequate to the objectives, and to a degree depending on the breeding system, may have to be given additional variation by recombination. Such considerations, though commonplace, are only too often neglected in practice. They deserve therefore particular emphasis. Until quite recently, Australia took little interest in broadening the genetic base of one of its most important crop plants, subterranean clover (*T. subterraneum*) a chance introduction of some seventy years' standing (cf. Frankel 1954). This has been remedied by two collecting expeditions to the Mediterranean, and breeding programmes are now giving this plant, which in effect was domesticated in Australia, a new evolutionary impetus.

In certain circumstances it may prove feasible and profitable to expose a population, representing an ample range of variation, to the impact of the new environment, allowing natural selection to raise the level of genetic adaptation. Such a programme is now under way in Australia on subterranean clover, under the care of my colleagues Dr. F. W. Morley and Mr. C. I. Davern. Two factors require special consideration. Firstly, natural selection will act on characters affecting survival rather than on those conditioning production; secondly, selection for competitive ability may be extraneous, and therefore irrelevant or even dysgenic, in relation to the ultimate constitution of the population. This is more likely to occur in self-fertilized than in cross-fertilized plants.

A number of experiments have provided significant evidence on these problems. Suneson (1956) found that natural selection in composite crosses increased fitness in terms of yielding capacity. In discussing these results Harlan (1957) recently stressed the value of a composite crossing programme in evaluating introductions. Gotoh (1956) on the other hand found that his highest yielding barley strains were not those with

highest competitive ability, hence in a mixed population the frequency of the former was likely to be reduced. In a wheat breeding programme in New Zealand the present author and his former colleague, Mr. L. G. L. Copp, carried out parallel selection on pedigree and bulk populations—kept for periods of from eight years onwards—on a large number of crosses. From the pedigree method resulted a number of highly successful lines, the best outyielding the standard variety by about 25 per cent.; the bulk method failed to yield any promising lines at all (cf. also Palmer 1952).

Just as the plant must be adapted to the environment, the environment may contribute its share to the adaptive process. It is the task of the agronomist or the ecologist, the forester or the horticulturist, to adjust the environmental component of the system. Success of an introduction will depend on the economic level of the heredity/environment adjustment.

Plant introduction is thus a co-adaptive system in which both components, heredity and environment, are in a dynamic state, with clear interactions (Frankel 1958). Indeed, a change in the environment may channel the adaptive process to levels or forms of production hitherto uneconomic, unexploited and perhaps unforeseen.

Physiology of Adaptation

For a rapidly growing number of economic plants, the elements of the physiology of growth and development — dormancy, germination, vegetative growth, flowering, seed production—are becoming known. Whole plant physiology is being adsorbed by agronomy, horticulture and plant breeding. It must constitute an indispensable aid to plant introduction.

To mention only a few of the more recent investigations, the significance of environmental factors in the regions of origin of introductions was recently discussed by Morley and Davern (1956) with relation to the cold requirement of subterranean clover; and Cooper's work in the genus *Lolium* has produced a wealth of information which could be applied in the re-settling of this genus in new environments (Cooper 1954, and earlier). The physiological nature of summer dormancy in perennial grasses—of great importance in regions with a Mediterranean type of climate—is being studied by my colleague Dr. H. J. Ketellapper. Preliminary results indicate that both moisture and temperature are contributing to dormancy; but that plants which continue growth when supplied with adequate moisture at low temperatures become dormant when the temperatures are raised even though water supply is not limiting.

Range of Adaptation

We have so far touched upon the physiological meaning of adaptation and on some genetic approaches towards adaptation. We must add the concept of range of adaptation, viz., the relative ability of genotypes to reach a certain performance level under a variety of environments. This is an important concept in plant introduction, as in any kind of plant improvement. Clearly the desirable degree of "adaptability" has to be assessed in each individual case. It seems unlikely that the highest levels of performance are often reached by "general purpose" types; yet adaptabilty is a desirable characteristic where the aim is less exalted and the demand is for ready establishment and survival. This developmental homoeostasis appears to be greater in hybrids than in inbred lines (cf., e.g., Lewis 1955). In *Poa pratensis*, Clausen (quoted by Gregor 1956) found a strain from a coastal bluff in Oregon which performs better than the best Norwegian strains at 1,500 feet in Norway, and is the only coastal strain to survive at 10,000 feet in the Sierra Nevada, where in turn it equals the indigenous strains. It is an apomict and, Gregor presumes, an extreme heterozygote. Clausen (1952, and personal communication) has found extreme adaptability in a number of his specific and

varietal Poa hybrids and concludes that wide crosses among genotypes which are geographically separated, may produce a range of adaptation far in excess of that normally found in nature. This approach is of importance to plant introduction wherever adaptability rather than specific adaptation is the aim.

Sources of Introduction

A review of the various attempts to rationalize plant collecting and exploration, to relate climate, ecology, floristics or other indices in potential donor and receptor regions, is beyond the scope of this discussion.* Nor is there a need to discuss further the opportunities offered to the plant collector in the "centres of diversity". It may be appropriate, however, to remark that Vavilov's character concepts were qualitative rather than quantitative; hence that the "centres" provide opportunities for gathering a multiplicity of variation rather than, of necessity, the highest degrees of character expression. For these, it seems plausible, one may to better effect search in the outlying niches where character development has been subjected to extreme environmental stresses.

Altogether, it seems, this subject might gain from a reduction of the scale from the global and climatic, to the ecological and microclimatic. Quite recently, an interesting suggestion was made by Hartley and Williams (1956). They find that "the typical meadow grasses of Europe—species of *Poa, Festuca, Lolium* and *Dactylis*—are allied to, and probably derived from woodland and forest margin types. So, too, are such tropical grasses as elephant grass and Guinea grass. . . . By contrast, none of the dominant species of the great temperate grassland regions —the steppes, prairies and pampas—are of importance in cultivated pastures." The authors ascribe this to the higher rainfall and fertility conditions in the areas in which the superior grasses evolved, and suggests that the failure to develop new pasture species in North America, in spite of prodigious efforts, may be due to the preoccupation with the preponderant prairie grasses—*Bouteloua, Andropogon,* etc.—to the neglect of minor forest-margin species.

Relative Environments

If it is difficult to relate the environments of the donor and receptor regions, it is almost equally difficult to devise efficient and economical proving methods for introductions in their country of adoption. Introductions are made, or marred, on the testing ground, hence its choice and management are all-important. Ecological considerations must predominate, and, in general, climatic considerations over edaphic. But it is essential that the latter be not overlooked, and among them nutritional aspects claim first attention. Depending on the nature of the proposed introductions, nutritional deficiencies or unbalances may have to be recognised and corrected before a significant test of introductions can be attempted. It would be futile to examine a potentially high-producing crop in a molybdenum deficient soil without adding the ounce of molybdenum which will correct the deficiency! Nor would it serve a useful purpose to examine introduced legumes without consideration for the associate Rhizobium. My colleagues at the Plant and Soils Laboratory, Brisbane, are investigating the potentialities of a number of subtropical legume species through a composite attack on nutrition, heredity, Rhizobium and management problems (cf. recent Annual Reports of Division of Plant Industry, C.S.I.R.O.).

If as yet we can see no way of dispensing with field tests for our introductions, with all the expense—and uncertainty—these involve, phytotronic facilities hold out great promise for plant introduction. This has been discussed by Went (1957). A graded series of controlled environments such as a phytotron provides could

*I cannot pass over this important subject without reference to the interesting suggestion of an "agrostological index" as a phytogeographical approach to pasture plant introduction (Hartley 1954b).

perform a threefold function. It could provide a reliable, rapid and efficient sieve for certain physiological characters; it would provide a means—and the only feasible one—of finding explanations for developmental shortcomings of introductions, and thus of devising solutions and remedies; and, last but not least, by delineating tolerance levels for environmental factors, it would make it possible to assess levels of general, and in some instances, of specific adaptability of introductions.

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(*Received for publication, July* 26, 1957).

TECHNICAL PAPERS

THE CONTROL OF MISTLETOE BY TRUNK INJECTION

By C. G. GREENHAM and A. G. BROWN

Summary

A description is given of the use of certain inorganic radioisotopes for following the movement of substances applied as solutions to holes drilled in the trunks of host plants. Movement to the leaves does not always follow such injection.

An account is given of investigations on 8 species of *Eucalyptus* for the control of mistletoe by trunk injections of 2,4-D. On 7 species reasonable commercial control, as would be of use in forestry practice, was obtained.

Introduction

A brief progress note on mistletoe* control described promising results from trunk injections of 2,4-D (Greenham *et al.* 1951).

Collaboration on this subject has continued between the Forestry and Timber Bureau and the C.S.I.R.O. Division of Plant Industry. In view of the increasing interest shown by others (e.g., Kadambi 1954; Kuijt 1954 and 1955; Gill and Hawksworth 1954), it is appropriate to give an account of the scope of the problem, to summarise results up till 1956, and to record some of the earlier work.

Mistletoe is a pest for a number of reasons. In agriculture it is a nuisance because it may kill shade trees. In water catchment areas the death of host trees may result in soil erosion. In forestry, mistletoe lessens yields even if it does not cause the death of host trees; Nicholson (1955) has shown that increasing degree of infection causes a rapid reduction in normal increment, and when 38 per cent. of the host crown is displaced by mistletoe, loss reaches 55 per cent. In some Australian states the sides of main roads are kept free from mistletoe. The reason for this is that the roads authorities are required to improve an area after constructing a main road through it.

Mistletoe is more widespread than is generally appreciated and its incidence is increasing. In a recent experiment at Gundaroo, N.S.W., in which 60 acres of woodland were treated as described later, over 30 per cent. of the eucalypts in the stand were infected, the degree varying with the species. May (1941), Hartigan (1953), and the N.S.W. Forestry Commission (1956) claim that mistletoe incidence is increasing. Records maintained by the Forestry and Timber Bureau for a 5-acre area at Kowen, A.C.T., which is divided into 114 plots, show that betweent 1952 and 1955 the number of infected plots has increased from 75 per cent. to 79 per cent. of the total number.

The Problem of Control

Information on the habits and distribution of mistletoe is given by Hartigan (1953), who points out that there is little possibility of control by means of insects or pathogens. The seeds are distributed mainly by birds.

Possums (*Trichosurus vulpecula* Kerr) show a marked preference for mistletoe foliage and fruits, and exert a controlling influence on its spread (Young 1937). It is probable that other native leaf-eating animals also exert some controlling influence. Zoological control of mistletoe is impossible under present conditions.

*Since the first note appeared, the revision of the Loranthaceae by Danser (1929) has become accepted. The genus **Loranthus** is now restricted to the S. American species. The former **L. pendulus** Spreng. now becomes **Amyema pendula** (Spreng.) van Tiegh.

Although the term "mistletoe" is used herein for any member of the Loranthaceae, the present investigations refer solely to **A. pendula.**

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The development of settlement has favoured the growth and spread of mistletoe, by the destruction of leaf-eating animals, and probably by increasing light intensity and bird density around remaining host trees. There is observational evidence that mistletoes grow best under conditions of high light intensity.

Until recently the principal methods of control were amputation of infected branches and destruction of the host trees. These methods have been used by Forestry Departments and Main Roads Authorities (Bureau of Investigations 1945), but they are expensive.

In 1947 the Forestry and Timber Bureau tried flame throwers for destroying mistletoes, as it was known that the parasites are more affected than the hosts in forest fires. However, this approach was not promising.

It appears that chemical control is the most feasible method available. The aim of the former and present investigations has been to find a selective systemic poison which, when injected into the host trunks, will kill mistletoes without injury to the hosts. Injections of 2,4-D were first tried in 1948. While these investigations were in progress Hartigan (1949) reported success with spray applications of 2,4-D, a method of control which is convenient when the trees are readily accessible. Nevertheless it is considered that trunk injections, if cheap and effective, would provide a more useful method in forestry practice.

This paper shows that trunk injections of 2,4-D will give reasonable control at low cost on a number of species of eucalypts. The many other poisons tested, which are not so satisfactory, are listed in Appendix 1.

Basic Work on the Movement of Poisons

Herbert (1931) showed that mistletoes could selectively accumulate certain elements from the host plants. Even when one mistletoe species parasited a second species, which parasited a third species (e.g., *Amyema pendula*), which in its turn parasited *Eucalyptus spp.*, there was always more potassium and phosphorus and less silicon and calcium in the parasite than in the preceding host.

This work suggested that it might be possible to obtain a selective systemic poison for mistletoe control. Copper sulphate, a known selective phytocide, was tried in the first tests (Greenham *et al.* 1951). This gave fair results, but not good enough, because about half the mistletoes always failed to respond. It was logical to conclude that the copper sulphate was not being translocated to the unresponsive mistletoes.

It was decided to use radioactive tracers for following the movement of injected substances. As radioactive copper has a short life, Fe^{59} was used in the initial experiment. This isotope has a half life of 44 days and a γ-emission of more than 1 Mev, i.e., high enough not to be markedly absorbed by leaf tissues. For the assay, discs $\frac{7}{8}$ in. in diameter were cut from the leaves and placed without drying against the window of the G.M. tube. For the following account, no correction has been made for the greater thickness and weight of the mistletoe discs; a dried mistletoe disc is 1.4 to 1.5 times the weight of a eucalypt disc, and the appropriate correction would increase the relative radioactive content of a eucalypt disc.

In July, 1948,* 0.025 mc. of $Fe^{59}Cl_3$, with inert carrier to make 1.6 grams of anhydrous salt, was applied to a 7.2 inch diameter trunk of *E. dives;* the ferric chloride was dissolved in 25 ml. of water at pH 2.0 with HCl, and subdivided between 7 holes in the trunk; a second trunk on the same roots was untreated. The treated trunk was infected with a small mistletoe on its third lowest limb and a medium-sized mistletoe higher up and closer to the trunk. Within three days, significant counts were obtained in leaf discs from the host tree but not in those from the mistletoes; the lower host leaves were more radioactive than the upper ones. 19 days after injection the

*This was the first botanical experiment done in Australia with a radioisotope.

amount of radioisotope in the upper host leaves had increased, possibly at the expense of those on the lowest branch; there was no radioisotope detectable in either mistletoe, though the leaves on the second lowest host branch were outstandingly radioactive and remained so throughout the experiment. 46 days after the injection, leaves of the lower mistletoe were doubtfully radioactive, those of the upper mistletoe significantly so, but not as active as the average of the host leaves. The experiment was continued for a total of a year, at the end of which significant but similar amounts of radioactive iron were present in both mistletoes; at least twice as much radioisotope was present in the host leaves, which were then approximately uniform in radioisotope content with the exception of those from the second lowest branch. No radioactive iron moved into leaves of the second trunk on the same roots.

This experiment shows that different amounts of an applied inorganic poison can be translocated into host and parasite leaves, that one branch of the host may be more affected than others, and that an adjacent trunk on the same root is not necessarily affected by the injection. The last two conclusions are in accord with observations on trees treated with copper sulphate. However, with arsenical compounds, when there are two trunks on the same roots, treatments applied to only one trunk may affect the second trunk.

Subsequently, three trees of *E. dives* were treated with $Co^{60}SO_4$, and another three trees with $Zn^{65}(NO_3)_2$, at various pH values. In terms of dosage rate (see next section) the radioactive dose was two or three times that in the experiment with $Fe\ Cl_3$, but the total dose was comparable. Even 6 months after application, no significant radioactive counts could be obtained in any leaves, though the one mistletoe on one tree treated with zinc nitrate died. It was noticed that all the injection areas remained highly active. An analysis was done on the radioactive zinc nitrate solution used, and it was found to contain 32 per cent. Cu, i.e., enough copper to kill a mistletoe. It may be added that the zinc nitrate preparation used was an early radioactive one, and had not been freed from copper by the suppliers.

The last experiment shows that the insertion of an inorganic poison into holes drilled in a trunk does not necessarily mean that the inorganic poison will move into the leaves. When the mixture of zinc and copper nitrates was used, the zinc stayed in the neighbourhood of the injection areas, whereas the copper was presumably translocated away and killed a mistletoe.

Work is in progress to determine the relative distribution of 2,4-D in host and parasite. It may be noted that 2,4-D is more readily translocated throughout the host plant than copper sulphate. With the latter it was found necessary to subdivide the dose between a number of holes, e.g., one per inch of trunk diameter, otherwise localised injury would occur in the crown. With 2,4-D, however, it has been possible to kill mistletoes on one side of a tree by applying a single dose to one hole in the opposite side. Application of of 2,4-D to only one hole, however, is not recommended (see next section).

Application and Calculation of Dose

An experiment was done with 2,4-D in December, 1952, to determine the possibility of using a few deep holes for injection (one-third to one-quarter of the usual number), instead of the usual one hole per inch D.B.H.* The results 26 months later are given in Table I. Similar results have been obtained with *E. robertsoni* using more concentrated 2,4-D solution and the lesser number of holes.

The use of a small number of deep holes caused increased crown injury in the hosts and decreased mistletoe kill, doubtless because of localised concentration of the poison in the host crown. Possibly better results would have been obtained with autumn injections, which give a slower response. In subsequent investi-

*D.B.H. = diameter of the tree at breast height. These diameters were determined by means of a tape calibrated to give a direct reading for the diameter.

TABLE I.

The effect of the number of points of application on results. E. polyanthemos as host.

Treatment	Mistletoes		Host
	Dead	Dead + Damaged[1]	Average Loss of Crown
1. Numerous[2] shallow holes, rate A[3] of 10 per cent. 2,4-D	53% (54)[4]	77% (79)	0%
2. Numerous shallow holes, rate B	88% (28)	100% (32)	5%
3. Few deep holes, rate A	37% (15)	50% (20)	15%
4. Few deep holes, rate B	42% (21)	48% (24)	20%

(1) Damaged = more than 50% defoliated.
(2) Numerous holes = 1 hole per inch of D.B.H.
(3) For rates see text.
(4) Figures in brackets denote actual numbers of mistletoes in each category.

gations one hole per inch D.B.H. has been used.

The method of calculating the dose, as used by Greenham *et al.* (1951), has been reasonably satisfactory, and the dose in ml. of 10 per cent. 2,4-D is determined by the expression Kd^2, where d is the D.B.H. in inches, and K is the dose factor determined by experimentation. In our experiments for the determination of the best value for K, we have increased the dose factor in multiples of $\sqrt{2}$, so that the dose rate increased in geometric progression, as is conventional in many pharmacological investigations. For convenience in field use, graphs have been prepared giving dosage in relation to D.B.H. (Figure 1). Unless otherwise

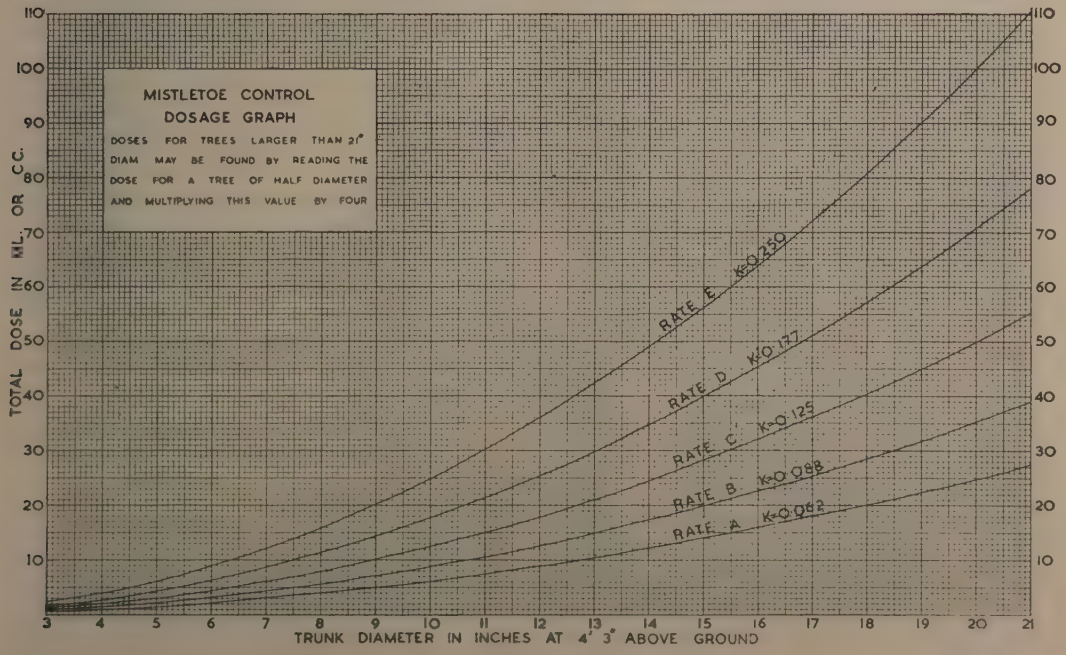

MISTLETOE CONTROL
DOSAGE GRAPH
DOSES FOR TREES LARGER THAN 21" DIAM MAY BE FOUND BY READING THE DOSE FOR A TREE OF HALF DIAMETER AND MULTIPLYING THIS VALUE BY FOUR
TOTAL DOSE IN ML. OR CC.
TRUNK DIAMETER IN INCHES AT 4' 3" ABOVE GROUND
RATE E K=0.250
RATE D K=0.177
RATE C K=0.125
RATE B K=0.088
RATE A K=0.062

Figure 1

TABLE II.

Response of mistletoe (Amyema pendula) and host (E. robertsoni) to 5 per cent. 2,4-D, in relation to time. Autumn application.

Trees	Equivalent rate of 10% 2,4-D	Inspection at 13 months		Inspection at 25 months	
		Mistletoes Dead	Host[1] Injury	Mistletoes Dead	Host[1] Injury
1-4	A	80%	0%	80%	0%
5-8	B	50%	0%	80%	0%
11-14	C	50%	0%	75%	0%
15-16, 18-19	D	100%	5%	100%	0%
20-21, 23-24	E	100%	15%	100%	15%
25-28[2]	C	0%	0%	60%	0%

(1) Average loss of crown by host. Usually recovery is rapid. (2) Holes punched, not bored.

stated, any of the investigations below have been done with 10 per cent. 2,4-D in 10 per cent. triethanolamine; this is the highest concentration of soluble 2,4-D that can be used without causing injury in the neighbourhood of the holes. To obtain 10 per cent. 2,4-D from the commercial 50 per cent. W/V preparation, 4 volumes of water are added to one of the commercial preparation.

Experiments and Results with Various Host Species.

E. robertsoni Blakely, and the Time Effect.

The previous paper (Greenham *et al.* 1951) gave results 13 months after an autumn application. An inspection 12 months later showed that remaining mistletoes were further affected.

Table II shows that excellent control was obtained with 5 per cent. 2,4-D applied at the equivalent of 10 per cent. 2,4-D at rate D in Figure 1.

It is likely that the effectiveness of a treatment will vary from year to year, and from district to district. Under local conditions it would be unlikely that less that 70 per cent. of the parasites would be killed by a suitable dose.

Applications have been tried at other seasons of the year, and the results obtained are given in Figure 2. In these and the subsequent experiments there were usually 5 replications, i.e., trees, per treatment.

In general, it is considered that a safe dose for *E. robertsoni* under A.C.T. conditions varies from rate C of 10 per cent. solution in spring (with the possible exception of October) to rate D in autumn. It will be noted from Figure 2 that in the October application, unthrifty hosts treated at rate C died, whereas the majority of thrifty hosts treated at a higher rate survived. This shows that the condition of the host trees at the time of application may influence survival.

With the above rates under local conditions a mistletoe kill of from 70 per cent. to 100 per cent. may be expected, with occasional weak members of the stand dying. If a greater risk is taken it is possible to increase these rates to D and E respectively with the possibility of losing up to about 10 per cent. of the stand. These losses probably occur because the method of dose calculation adopted does not fully compensate for variations in crown size and vigour of the host tree. The problem may be approached in either of two ways:

(1) By giving the weak trees a reduced dose, the reduction being estimated by eye, or

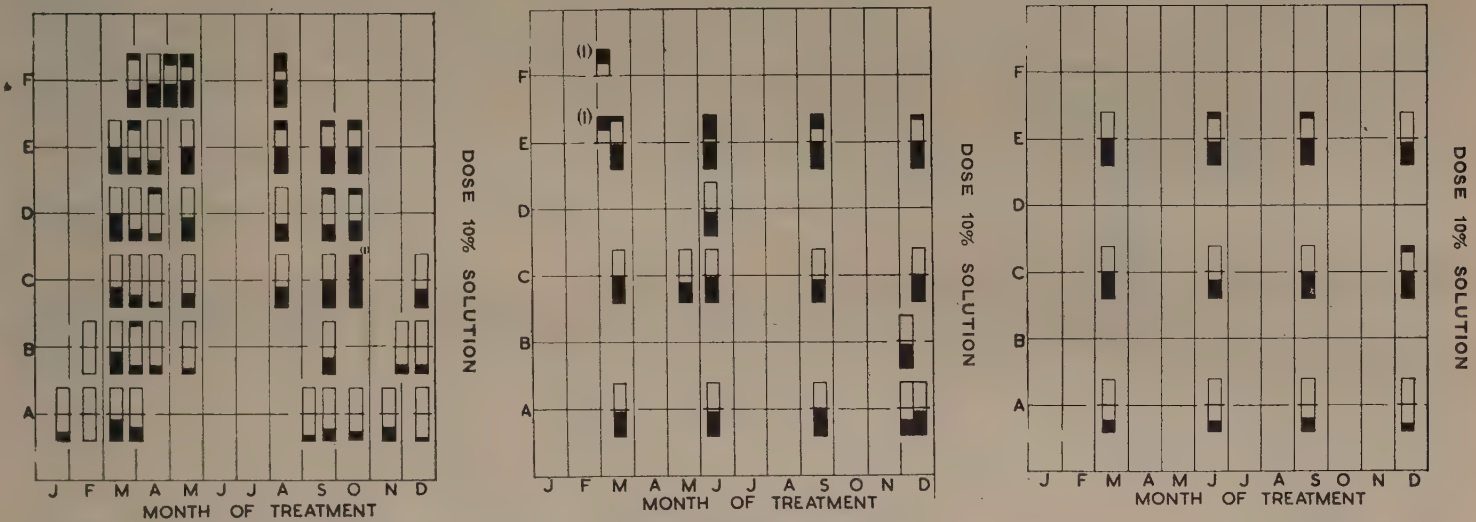
(2) By giving all trees the normal dose, disregarding the deaths which do occur, as these will be generally confined to unthrifty, suppressed, or very heavily infected trees which contribute little to the increment of the stand and would

Figure 2.

GRAPHS SHOWING THE EFFECT OF 2,4-D INJECTIONS.

(a) on mistletoe and Narrow-Leaved Peppermint (*E. robertsoni*) **(b) on mistletoe and Red Box (*E. polyanthemos*)** **(c) on mistletoe and Red-Stringybark (*E. macrorrhyncha*)**

at various times and rates of application.



(1) Hosts unhealthy when treated.

(1) No mistletoe present.

For example

The proportion of shading here indicates the % deaths among the hosts, here 50%.

The proportion of shading here indicates the % deaths among the mistletoes, and here is 75%.

probably die relatively soon in any case. Such deaths are considered unimportant in most forest areas, when the dead trees may be utilised in one way or other. The injection method of control is a considerable improvement on that adopted by Hawkesworth and Lusher (1956), who utilised or destroyed every infected tree in a pine stand.

E. polyanthemos Schau. Rate C has given a mistletoe kill averaging over 85 per cent. in the tests conducted without causing much temporary crown loss or any permanent damage to the trees treated (Figure 2). It is probable that rate D could be used satisfactorily during autumn and winter with very few deaths among the hosts. Occasional splitting of the bark may result from the injection of 2,4-D, but is not regarded as serious. Such splitting can occur even in untreated trees, particularly during a wet season.

E. macrorrhyncha F.v.M. Rate C gave an average mistletoe kill of 93 per cent. with a loss of 6 per cent. of the hosts (Figure 2). It is considered that this rate would be reasonably suitable for use through out the year, occasional deaths among the hosts being possible. Less host damage or loss would probably result if summer treatments were omitted.

E. camaldulensis Dehn. In an experiment at Alice Springs laid down in May, 1953, rates C and D of 10 per cent. solution gave good mistletoe kills but caused some temporary partial defoliation.

Experiments on other Species by other Organisations

Following the early results obtained at Canberra, work on similar lines was undertaken by some State Forest Services and the University of Melbourne. The following comments are based on interim results which have been obtained on other species.

E. pilularis Sm. Experiments conducted by the Department of Forestry, Queensland, have shown that treating this species with 2,4-D at the equivalent of rate A of 10 per cent. solution gives results comparable with those obtained at Canberra on *E. polyanthemos*. (Private communication).

E. maculata Hook. The Queensland Department of Forestry has also carried out experiments on this species. However, results were not as satisfactory as with *E. pilularis*. (Private communication).

E. hemiphloia F.v.M. Experiments conducted by the Forests Commission of Victoria on this species with rate C of 10 per cent. 2,4-D have given results as good as those obtained on *E. polyanthemos* at Canberra. (Private communication.)

E. sideroxylon A. Cunn. ex Benth. Experiments have been done by the School of Forestry, University of Melbourne, on this species. At rates equivalent to D and E of 10 per cent. 2,4-D, good mistletoe kills have been obtained, though a few host deaths occurred at the higher rate. (Private communication).

Reasonably satisfactory results have been obtained on 7 of the above 8 host species. Accordingly the results indicate that the method of treatment described in this report may be suitable for destroying mistletoe growing on a wide range of eucalypt hosts. However, pilot trials in any particular locality or on other species should be done before large scale work is undertaken. In this connection it is again emphasised that results frequently do not become evident for six months or more after treatment, and that two years may elapse before mistletoe deaths cease to occur. Under local conditions autumn treatments are preferable.

No work has been carried out by the authors on host species of other genera. Considerable variation in the reaction of the host to 2,4-D could be expected, in view of other work in this field (Singh 1955). Work on Kurrajong (*Brachychiton populneum* R.Br.) is being carried out by the Forestry Commission of N.S.W.

TABLE III.

The effect of retreating mistletoes surviving an earlier treatment. E. polyanthemos as host.

Treatment	Condition at 4/6/53			Condition at 22/4/55		
	Mistletoe		Host	Mistletoe		Host
	Dead	Dead+ Damaged[1]	Crown[2] Defoliation	Dead	Dead+ Damaged	Crown Defoliation
1. Single treatment (15/5/51) Rate C, 10% 2,4-D	56%	100%	0%	60%	60%	0%
2. Not previously treated. Treated 4/6/53 at Rate D	0%	0%	0%	88%	92%	0%
3. First treated 15/5/51 at Rate C	75%	98%	0%	74%[3]	84%	7%
Retreated 4/6/53 at Rate C	(40)[4]	(52)		(46)	(52)	
4. First treated 15/5/51 at Rate C	73%	100%	0%	87%	91%	8%
Retreated 4/6/53 at Rate D	(35)	(48)		(46)	(48)	

(1) Damaged = more than 50% defoliated.
(2) Crown defoliation = temporary loss of crowns by host.
(3) Apparent reduction here due to appearance of new mistletoes.
(4) Figures in brackets denote actual numbers of mistletoes in each category.

Retreatment of Surviving Parasites

As the 2,4-D treatment does not invariably kill all mistletoes, an experiment was conducted at Tharwa, A.C.T., in which mistletoes surviving two years after the host had been treated with 10 per cent. 2,4-D at rate C were retreated with the same solution at rates C and D. A number of surviving mistletoes which were not retreated were used as controls.

The original treatment was carried out on 15/5/51. The retreatment was carried out on 4/6/53, and the results in Table III are based on final observation made on 22/4/55.

In both treatments 3 and 4 the total number of mistletoes at the end of the experiment was greater than at the commencement. This is due to the appearance of a number of new infections on the treated trees during the period of observation. These small plants appeared quite healthy at the conclusion of the experiment, although older established plants were dead or dying. Almost all the parasites surviving the treatment, particularly at the higher rate, were young plants, which have been found to be the most resistant.

There is no evidence of a marked increase in either susceptibility or resistance on the part of host or parasite, although temporary defoliation of the hosts occurred in treatments 3 and 4. Apart from defoliation, the final figures for treatments 2 and 4 (treatment and retreatment at rate D) are very similar.

Most of the parasites which survived the original treatment (treatment 1) recovered much of their former vigour during the period of observation, i.e., from two to four years after the original treatment was applied.

Subsequent observation on the trees in this experiment, which is located in savannah woodland very heavily infested

TABLE IV.

Results of 2,4-D application in axe cuts. E. polyanthemos as host.

Treatment	Mistletoe		Host	
	Dead	Dead + Damaged(1)	Deaths	Average Crown Loss
Rate C of 10% 2,4-D	70%	86%	7%	2%

(1) Damaged = more than 50% defoliated.

with mistletoe, has shown that there is a high rate of reinfestation of the treated trees, doubtless due to birds. It is therefore impractical to aim at complete destruction of mistletoe in a treated area. A more practical approach is to aim to kill 70 to 90 per cent. of the parasites, and retreat every 5 years.

Rapid Application of the Poison

In April, 1954, an experiment established at Kowen utilised a light axe for making cuts to hold the poison, which was applied with a drenching gun in units of 4 ml. When inspected 28 months after establishment the following results were obtained, Table IV,

The results of this experiment were considered to be sufficiently encouraging to warrant further investigation along these lines. The kill obtained is not as high as that obtained using the same rate of application to bored holes, probably because some loss of solution from the wood to the bark occurred, reducing the effective dose which the tree received.

Subsequently, a test was established to determine the cost of treatment and its efficiency under commercial conditions. A modified axe with blade reduced to 2 in. width was used to make cuts in the trunk to hold the poison. The dose per tree, which was formerly determined by measuring the D.B.H. of the tree and reading the required dose from a table or graph, was determined directly by means of a modified Biltmore stick (Bruce and Schumacher 1942, p. 9). This gave the number of cuts required per tree of a given size and the number of applications of poison per cut, applied from a drenching gun. It was found possible to treat trees averaging 18 in. D.B.H. for an average total cost of sixpence each, including labour. Further details of this experiment will probably be published later.

Tests of Chemicals in Progress

A list of chemicals which are currently being tested is given in Appendix (E). In the trials laid down on 25/3/55, 2,4-D + potassium metaborate, the hydrazine salt of 2,4-D, and 2,4-D + 2,4,6-T in mixture are at least as good as 2,4-D. Final details of these tests will be published later. Because the hydrazine salt is rapid in action and has other useful properties, an application has been lodged for a patent covering its use as a selective herbicide.

Conclusions

(1) It is possible to kill from 70 to 100 per cent. of the mistletoes (particularly *Amyema pendula*) growing on several species of eucalypt hosts by injecting a solution of the triethanolamine salt of 2,4-D into the host tree. This treatment may cause temporary partial defoliation of some of the host trees treated, and some 5 per cent. of the hosts may die.

(2) About one-half of the parasites remaining two years after treatment may be killed by a second treatment at the same rate. The original treatment does not cause marked changes in resistance to 2,4-D in either the host or parasite.

(3) The treatment of only individual trees or groups of trees in an infected stand is not entirely satisfactory because reinfestation rapidly occurs. In such cases, a treatment which gives 80 per cent. kill is practically as good as one which gives 99 per cent. kill.

(4) Application procedures which have been developed make the treatment of large areas a practical possibility. Little capital equipment is required for this work.

(5) Further experiments are in progress with a view to increasing the efficiency of the treatment and decreasing loss or damage in the host trees.

Acknowledgements

Due acknowledgement is given to J. M. Fielding and C. D. Hamilton, of the Forestry and Timber Bureau, and D. I. Nicholson formerly of the Bureau, who participated in some of the earlier work described herein. W. Bateman of the Bureau was responsible for the trials at Alice Springs.

Acknowledgement is given also to the State organisations cited, for results obtained on other species of eucalypts.

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Appendix

List of Chemicals Tested as Injections

(2,4-D and its derivatives were dissolved in triethanolamine unless otherwise stated.)

A. *Chemicals producing no marked effect, or affecting both host and parasite equally.*

Ammonium sulphate[1] (25%*, 80†); ammonium thiocyanate[2] (33%, 80); arsenic pentoxide[3] (solid, 1); arsenic trioxide[1] (solid, 2); barium chloride[1] (30%, 80); calcium chloride[1] (25%, 80); chrome alum[1] (20%. 80); copper sulphate[1] (solid, 20); 2,4-dichlorophenoxy acetaldehyde (bisulphite compound)[1] (7½% in water, 20); 2,4-dichlorophenoxy ethyl phosphate[1] (10% in water, 15); β-(2,4 dichlorophenoxy) propionic acid[2] (10%, 20); 3,4-D iso-octyl ester[1], equiv. to 10% 3,4-D acid (10% emulsion, 20); Dinoc[1] (10%, 160); ferrous sulphate[1] (25%, 80); magnesium chloride[2] (25%, 80); magnesium sulphate[1] (25%, 80); manganous sulphate[1] (25%, 80); mercuric chloride[1] (5%, 40); α-naphthaleneacetic acid[2] (10%, 40); sodium chlorate[8] (25%, 80); strontium nitrate[1] (30%, 80); zinc sulphate[1] (25%, 80).

B. *Chemicals affecting the hosts more than the parasites.*

Ammonium trichloracetate[4] (15%, 80); Methoxone[5] (10%, 60); potassium chromate[5] (20%, 80).

C. *Chemicals affecting the parasites more than the hosts but of little promise.*

Ammonium sulphamate[6] (solid, 10); β-chlorophenoxyacetic acid[7] (10%, 20); 2,5-D[8] (10%,

*The percentage figure in brackets indicates the concentration of the solution used.

†This figure indicates the maximum amount of the solution in mls. or solid in grams which would be applied to a 9 in. diameter tree; the results for this maximum amount are given in the accompanying footnotes.

1. No effect on either host or parasite.
2. Slight defoliation of both host and parasite.
3. Severe defoliation of both host and parasite.
4. Moderate defoliation of hosts; parasites unaffected.
5. Moderate to severe defoliation of hosts, parasites less affected.
6. Some hosts and an appreciable number of parasites killed.
7. Hosts unaffected, parasites defoliated.
8. Hosts unaffected, up to 33% of parasites killed.
9. Hosts unharmed, up to 30% of the parasites killed.
10. Hosts moderately defoliated; up to 50% of the parasites killed.

14); 3,4-D[8] (10%, 20); sodium arsenite[8] (10%, 10); sodium sulphate[7] (25%, 80).

D. *Chemicals affecting the parasites more than the hosts and showing appreciable selectivity.*

Copper chlorate[8] (solid, 10); copper sulphate[10] (25%, 100); 2,4,5-T[8] (10%, 20); 2,4,6-T[8] (10%, 40); 2,4-D (various; see text).

E. *Chemicals currently under test.*

γ-(4-chloro-2-methyl phenoxy) butyric acid;
γ-(2,4-dichlorophenoxy) butyric acid; 2,4-D + acetamide;
2,4-D + potassium metaborate (applied separately);
2,4-D + 2,4,6-T; 2,4-D + triethanolamine borate;
2,4-D + tri-isopropanolamine borate;
2,4-D ammonium salt (in Carbowax suspension);
2,4-dichlorophenoxyethanol (in Taubman's solubiliser);
2,4-D glycerol ester (in Taubman's solubiliser);
2,4-D glycine analogue; 2,4-D hydrazine salt (aqueous suspension in Carbowax);
2,4-dichlorophenoxyacetonitrile (in Carbowax suspension);
2,4-D urea compound (in Carbowax suspension);
γ-(2,4,5-trichlorophenoxy) butyric acid.

(*Received for publication, October* 28, 1957.)

BOOK REVIEWS

CHEMICALS, HUMUS, AND THE SOIL

By DONALD P. HOPKINS

(*Faber and Faber Ltd., London, Revised Edition*, 1957, *pp.* 288. *Price* 25/- *Stg.*)

This book is a counter to the claims of certain sections of the English organic school of thought that chemical fertilisers are wholly bad. First published in 1945, the revised edition is substantially rewritten and expanded, but maintains the original theme that soils need both humus and fertilisers and there need be no controversy about their respective places.

The author presents the case for fertilisers in Part I, discussing the replenishment of nutrient losses from the soil, the organic matter cycle, and the action and properties of individual fertilisers and organic manures. He draws freely from the results of scientific experiments with NPK fertilisers and organics.

Part II presents the case against fertilisers, dealing with the effects of chemicals and humus on soil organisms, plant health and food values.

Part III is an addition to the book and puts the case for greater fertiliser use based on the expanding needs of grassland in recent years. It also deals briefly with the economics of fertiliser use and overseas consumption.

The book is written for the English environment and is primarily intended for the layman farmer and gardener. However, it should be valuable to all the uninformed seeking information on the principles of soil fertility maintenance. Facts and arguments are presented clearly while technical terms have been kept to the minimum.

J. K. M. SKENE.

CONTROL OF BLUE MOULD (*PERONOSPORA TABACINA*, ADAM) IN INFECTED TOBACCO SEEDLINGS

By M. MANDRYK

Summary

In glasshouse experiments 5 ml of benzol each night prevented occurrence of blue mould in inoculated tobacco (*Nicotiana tabacum* L.) seedlings held in trays measuring 0.5 sq. m., provided that the use of benzol was commenced not later than 24 hours after inoculation. If seedlings were left untreated for from 2-6 days after inoculation the quantity of benzol had to be increased to 10-30 ml in order to obtain a high percentage of healthy seedlings. Benzol applied in the late stage of incubation of the pathogen may mask the disease and the organism becomes active again after cessation of treatment.

Introduction

Blue mould was prevented by the use of benzol at or before the time tobacco seedlings were inoculated (Angell *et al.* 1935). If benzol was used in seedbeds after sporulation occurred the disease was not effectively controlled (Allan *et al.* 1938). Other investigations (Angell 1957) showed that losses of up to 50 per cent. of the crop occurred as a result of transplanting seedlings from badly-managed seedbeds. It was considered that the disease occurred because inadequate quantities of benzol were used and its application was delayed until after infection.

The length of the period between infection and the application of benzol influences the degree of control. If the infection is present in seedlings before benzol is applied, and if the recommended rate of application of two sq. in. of benzol per sq. ft. of bed area is used the disease may be masked but will appear if benzol treatment is discontinued or after transplanting. The objective of the present investigation is to determine the amount of benzol necessary to inactivate the pathogen within tobacco seedlings during the period from inoculation to appearance of fructification.

Methods and Materials

Seedlings were grown in flats or pots and inoculated, as reported previously (Hill and Mandryk 1956) then placed for up to two days in a humidity cabinet where night and day temperatures were 60 and 70°F., respectively, and the relative humidity near saturation. They were removed to glass-covered iron trays in which they could be treated with benzol. Benzol treatment was always used for six consecutive nights, but the time of commencement varied from 0 to 6 days after inoculation. The temperature range during this phase of the experiments was from 60-88°F. and the relative humidity was favourable to disease development. Tests were made using 5, 10, 15, 20 and 30 ml benzol and an evaporation surface equal to 1/200 of the tray area. During treatment with benzol the plants were covered continuously during the day to prevent fresh infection and, at the conclusion of treatment, each pot of seedlings was removed and covered with a bell jar for 20 days before being finally examined for blue mould occurrence. If the plants were then disease free, it was concluded that the pathogen had been killed. There were no significant differences in results of tests made at different times.

Results

The pathogen did not survive when 5 ml of benzol was applied within 24 hours

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TABLE I.

Effect of benzol on occurrence of blue mould of tobacco when used at different rates and times after inoculation of seedlings.

No. of Seedlings	Benzol treatment		Disease Rating of Seedlings*			
	Time after inoculation (days)	Amount (ml)	1	2	3	4
			%	%	%	%
64	0-1	5	100	—	—	—
32	2		12.5	15.7	71.8	—
76	3-4		1.3	19.7	68.5	10.5
72	5-6		—	4.4	44.4	51.2
32	2	10	81.2	18.8	—	—
64	3-4		37.5	46.8	15.7	—
64	5-6		14.0	37.5	45.5	3.0
64	2	15	100	—	—	—
88	3-4		41.0	48.8	10.2	—
84	5-6		18.9	53.1	25.0	3.0
64	3-4	20	64.0	34.5	1.5	—
96	5-6		32.0	57.0	11.0	—
112	3-4	30	93.7	4.6	1.7	—
64	5-6		82.8	9.4	7.8	—
607	1-20	nil	—	—	—	100

*1. Healthy.
2. Fructification.
3. Fructification and systemic infection.
4. Dead.

after inoculation of seedlings with a spore suspension. If the application of 5 ml was delayed for a longer period the plants became diseased. When 10 ml of benzol was used at 2 days after inoculation, the disease was eliminated from 81 per cent. of the plants; from 37 per cent. if used after 3-4 days and from 14 per cent. if used after 5-6 days. Increasing the quantity of benzol to 15, 20 or 30 ml led to a progressive improvement in the percentage of disease free seedlings (Table I).

The increased quantities of benzol appear to have been required, in part, to counteract the deeper penetration of plant tissues by the pathogen. Microscopical examination showed that, within 24 hours, the mycelium was established in the epidermal and upper mesophyll regions where it was killed by an application of 5 ml of benzol. During the following 24 hours the mycelium was established in the intercellular spaces of the middle mesophyll and was not destroyed when benzol was used at the same rate. Leaves from such plants when removed after treatment and placed in moist chambers developed fructification.

Growth abnormalities occurred in leaves at the high rates of application but normal leaves were produced after the use of benzol was discontinued. Many heavily diseased leaves were shed after treatment. All untreated plants became diseased, with heavy sporulation on the 6th day after inoculation and died within 15-20 days.

Discussion

Wolf *et al.* (1939) stated that if seedbeds were treated 2 days after symptoms appeared, 4 times the usual amount of benzol used in a single application was necessary to obtain control. Clayton *et al.* (1942) showed that 0.5 fluid ounces of

Figure 1.
Tobacco seedlings photographed 20 days after last benzol treatment. Front row 5 ml and back row 20 ml benzol for each of 6 nights commencing 4 days after inoculation.

benzol per square yard of seedbed (about 156 ml per 100 sq. ft.) gave distinct but not perfect control, but twice that amount gave complete control without injury. Allan *et al.* (1938) showed that blue mould could be prevented by using benzol at an evaporation surface of 1/72-1/100 of the seedbed area. When the disease occurred before the use of benzol was begun or when insufficient was used, the 1/72 ratio applied continuously for three days and nights, followed by the 1/100 ratio at night only, prevented further spread. Even then, some of the seedlings apparently remained infected, the disease appearing subsequent to transplanting.

In these glasshouse experiments, control obtained in the early stage of infection by vapour of 5 ml of benzol at an evaporation surface of 1/200 of the seedbed area was approximately equivalent to that obtained by Allan *et al.* (1938) with 0.33-0.41 gallons benzol per 100 sq. ft. of seedbed and an evaporation surface of 1/72 of the seedbed area. From these figures 92 ml of benzol in the glasshouse experiments gave control comparable with 1510-1860 ml in farmers' seedbeds. The small quantity of benzol used in the glasshouse was effective because the benzol vapour was retained in the covered seedbed area. This was particularly evident at the higher rates when the odour of benzol could be detected when the cover was removed after 24 hours even though all benzol had evaporated in less than 16 hours. These results emphasise the importance of relating the quantity of benzol evaporated, to the means used to retain the vapour in seedbeds. However, when the organism established itself in the middle mesophyll or slight fructification occurred the quantity of benzol necessary to check the disease had to be raised by 3-4 or 6 times the amount adequate if used immediately after inoculation (Figure 1). Benzol applied in the later phase of incubation usually did not eliminate the pathogen in all plants and resulted in masking of the disease. Thus symptoms of the disease were not apparent in plants treated for six nights with 5 ml of benzol commencing on the third day after inoculation but, after being placed under bell-jars fructification and systemic infection occurred on two-thirds of them. If these apparently healthy plants were included with healthy seedlings during transplanting they would provide sources of infection in the field. However, it appears that under some conditions the disease may be localised in the stem near the soil level and its effects in the field are shown by death or arrested growth or by apparent resistance to leaf infection (Angell 1957). These effects together with the necrosis and extreme brittleness usually present at the base of diseased stems have often been observed in our heated glasshouses and they suggest the presence of a toxin, one effect of which can be wilting (Wolf 1934). It may be concluded therefore that an efficient use of a small quantity of benzol will ensure control of the disease in the early stage of infection but if applied later its action may be only fungistatic and the pathogen will resume growth when treatment is discontinued.

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(*Received for publication, September* 25, 1957).

BOOK REVIEWS

THE UNDERGROUND ORGANS OF HERBAGE GRASSES

By ARTHUR TROUGHTON

(*Welsh Plant Breeding Station, Aberystwyth.*)

(*Commonwealth Bureau of Pastures and Field Crops, Bulletin* 44. *Obtainable from the C.A.B. Liaison Officer at* 314 *Albert Street, East Melbourne, Victoria. Price* 31/3.)

Mr. Troughton has rendered a valuable service in accumulating within one bulletin the significant findings of many investigations concerning the underground organs of herbage grasses.

The book provides a comprehensive account of the roots, rhizomes, corms, bulbs and leaf bases of herbage grasses. A description of their morphology, anatomy, life history and chemical composition is followed by a discussion of the effects of environmental factors and farming practices upon their growth, and the relationship between the underground organs and the growth of herbage. The decay of the underground organs and their effect on the soil are dealt with, and the methods used in studying these organs are also reviewed.

The book simply and clearly summarises present knowledge regarding the growth structure and functions of roots, and it does not conceal the fact that there is still much to be learnt in this important but largely neglected field of study. The agricultural interest in this work is concerned with the part that underground organs of grasses play in the production of herbage and in the improvement of soil fertility.

Despite the acknowledged importance of soil nutrients and moisture in determining pasture productivity in Australia, little is known regarding the functioning and efficiency of the absorption organs of plants. It is obvious that the investigators of root systems will encounter difficulties discouraging to those usually concerned with the more familiar above-ground organs.

Mr. Troughton's book should stimulate interest in this field of inquiry, and should prove a valuable guide to those who, prepared to accept the challenge of untrodden paths, have the wisdom to profit from the experience of others.

R. L. TWENTYMAN.

A SALINITY SURVEY OF THE MIRROOL IRRIGATION AREA

By H. GROENEWEGEN

Summary

Results of a salinity survey in the Mirrool Irrigation Area are briefly described.

Salt occurrence was related to topography, occurrence of watertables, and irrigation methods used. Flood and spray irrigation were found to be far superior to furrow irrigation in preventing salt accumulation.

It is concluded that the general conditions in the Area are not particularly conducive to salt accumulation.

Introduction

In this paper some observations made during a Reconnaissance Survey on soil salinity in the Mirrool Irrigation Area will be briefly discussed.

The climate is semi-arid, with an average rainfall of 15.5 in., and no distinct seasonal maximum. Irrigation water is of a very high quality, total soluble solids 88 p.p.m., while divalent cations are present in larger quantities than sodium (Cassidy 1949).

Chlorine is the principal anion in the saturation extract of these soils, except in some of the slightly saline profiles where sulphate predominates (Groenewegen, unpublished data, 1956).

The occurrence of salt in the soil was assessed by its effect on plant growth, such as severe leaf-burn and stunted growth. Leaf samples were taken from affected and non affected patches and the chlorine contents determined to confirm these observations. A large number of conductivity readings on groundwater was also used to indicate salt occurrence; chlorine and conductivity measurements of 1:5 suspensions and saturation extracts were made on samples of selected profiles.

A soil was considered to be salty when the conductivity of the saturation extract exceeded 4 millimhos/cm, or when 0.1 per cent. of salt occurred.

Results

(a) *Incidence of Salting*

In this Area the presence of salt at lower depths is an essential condition for the accumulation of high quantities of salt in the surface (0-2 ft.) layers (Groenewegen, unpublished data, 1956).

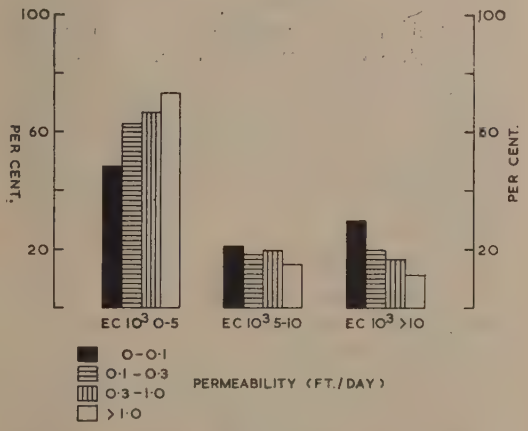

Figure 1.
Percentage of soils with groundwater of low, medium, and high conductivity (millimhos/cm. = $EC10^3$) in each group of soils with different permeability (averages of 1,500 samples).

In soils with a permeability of 1 ft/day or higher, less than 30 per cent. of the groundwater has a conductivity greater than 5 millimhos/cm (Figure 1). Most of the serious salt damage in the Mirrool Area occurs in these soils, when conditions have favoured salt accumulation in the surface layers. (Conductivity of the saturation extract of the A horizons after a dry period varied between 4 and 49 millimhos/cm.). The actual proportion of permeable soils with groundwater of

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medium or high salinity is probably somewhat smaller because the groundwater samples were collected from farms investigated for tile drainage. These farms were, as a rule, to some degree affected by salting.

A larger proportion of saline groundwater occurs in the more impermeable soils (Figure 1). In contrast with the permeable soils salt and chlorine concentrations increase with depth, and large areas with saline groundwater have very low salt contents in the surface layers (Groenewegen, unpublished data, 1956).

(b) *Some Factors Influencing Salt Accumulation*

For a more comprehensive exposition of the Survey's findings it has been considered desirable to group under certain headings the information gathered on various factors found to be of most importance in salt accumulation. Their inter-relationship however should not be forgotten.

(1) *Topography*

The occurrence of salty soils can be most readily related to the general topography of the Area.

Taylor and Hooper (1938) discussed in detail the topography of the Murrumbidgee Irrigation Areas (M.I.A.). Part of the Irrigation Area is situated on the colluvial soils of the McPherson Range, a small scarp ridge which rises about 300 ft above the general level of the plain.

The survey reported here indicated that no salt occurs on the irrigated, well drained, colluvial soils of higher elevation. A high incidence of salting was found on the colluvial soils of the lower slopes of the McPherson range, especially in the drainage ways and at the end of the slope. This is due to seepage and a high occurrence of salt under virgin conditions.

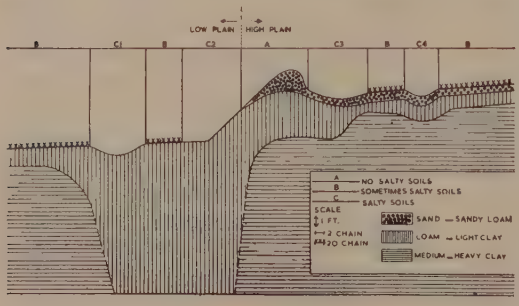

Figure 2.
Relation between topography and salt accumulation.

South and east of the McPherson Range fairly flat plain country occurs. Figure 2 shows a typical traverse south of the McPherson Range. Heavy soils occur on a plain of gentle contour gradients. Another pattern of soils occurs after a relatively sharp fall of 6-7 ft in elevation. Low sandhills are found here in association with soils of greatly varying structure and texture. There are thus two plains at different levels and these will be referred to as "high" and "low" plains. The boundary between the "high" and the "low" plains is usually covered by windblown sands and silts. At 11 ft or deeper a heavy impervious clay occurs in both cases (Taylor and Hooper 1938).

No salty soils are found on the sandy ridges and tops of local sandhills (A in Figure 2). This is apparently due to low watertables and good drainage. Salt is sometimes found on flat land (B in Figure 2). Since no great influence from seepage can be expected here the salting can only be due to the formation of watertables, and the uneven distribution of water unavoidable in furrow irrigation. The highest incidence of salting is found in weakly developed depressions (6 in-1 ft deep, up to 3 acres in area) which are surrounded by flat land (C_1 and C_4 in Figure 2), on the lower slopes of local hills and on the lower slope of the boundary between the "high" and "low" plains (C_2 in Figure 2). A high salt incidence is also found in the weakly developed depressions between local sandhills (C_3 in Figure 2). This salt occurrence is still pronounced even if these dunes are surrounded on three sides by the "low" plain and the depression proper is 5-6 ft above the normal level of this plain. Figure 2 shows that a heavy impermeable layer occurs at 4-5 ft below the

surface. Watertable levels at approximately 3 ft in the soils of this depression indicate that water movement in the impermeable layer is very slow. Such localities are much more prone to salt accumulation than areas with similar soil conditions on the plain proper. The high incidence of salting on most locations, indicated by C in Figure 2, may be partly due to higher than average salt concentrations under natural conditions, but salt accumulation to the surface has also been aggravated by subsequent upward seepage.

It was found (Groenewegen, unpublished data, 1956) that the salts of the surface 3 ft of the soils of the high plain have been mostly derived from the irrigation water. The depressions on this high plain (C_4 in Figure 2) have always suffered from overwatering, and this will increase the salt concentration on such spots. The more permeable nature of the first 4 ft of the soils of the depressions than of the other soils of the high plain will further facilitate salt accumulation to the surface during periods favouring such a salt movement. Even in these depressions conductivity of the saturation extract does not exceed 8 millimhos/cm.

(2) *Watertable*

A study of salt occurrence in M.I.A. soils showed that in most cases it was associated with the presence, to date or at some earlier date, of a high watertable. Winter watertable readings (Jackson, unpublished data, 1955) taken over a large number of years showed that heights above 8 ft are fairly general in the Mirrool Area. Although a large part of the Survey was carried out during the dry winter of 1954, most salty soils on land irrigated for a number of years had a watertable higher than 3 ft 6 in. In a particular district, where no extensive salt accumulations occurred, watertables higher than 8 ft were found only occasionally, and this is explained by unsaturated sandbeds at approximately 30 ft below the surface (Jackson, unpublished data, 1955).

In discussing the necessity of a high water table for surface salt accumulation Kelley (1951) mentions that workers in the Punjab have found salt accumulation without the presence of a high watertable. It is therefore of interest to note that during this Survey, salt accumulation was observed on light textured soils which were irrigated for the first year with the furrow irrigation method, although no high watertable had developed.

(3) *Irrigation methods and crops grown*

Richards *et al.* (1954) described the beneficial effect on salty soils, of all irrigation methods which tend to give an even distribution of water. It was found in the course of this Survey that under similar topographic and soil conditions, different irrigation methods were responsible for large differences in salt accumulation. It is worthwhile, therefore, to consider the effect of each method separately.

(i) *Spray irrigation*—Spray irrigated orchards, under similar soil and topographic conditions were found to be much less damaged by salting than furrow irrigated ones. The advantages of spray as against furrow irrigation under M.I.A. conditions was also demonstrated by Spencer (unpublished data, 1947). He grew carrots in a permeable soil (Hanwood Loam) which, although not irrigated for years, had a watertable between 2 and 3 feet. Before irrigation began surface salting was assessed on appearance of soil and of the volunteer vegetation, it was somewhat higher on the spray irrigated blocks than on the furrow irrigated blocks ($13\frac{1}{2}$ as against $5\frac{1}{2}$ per cent. of the total area).

Results of his experiment can be summarized in Table I.

TABLE I.

Effects of irrigation methods on carrots.

Irrigation Method	Furrow	Spray
Number germinated . .	602	1,335*
Per cent. survival of germinated crop	49	97*

* $P < 0.01$

It should be pointed out that this experiment was carried out on one of the saltiest soils of the districts where upward seepage aggravates the problem.

(ii) *Place of furrows*—It seems likely that in this district the distribution of irrigation water, associated with the growth of different crops, is a contributing factor to differences in surface soil salinity. For example, vineyards suffer less from salt damage and have less surface salt accumulation than other orchards, and this can be ascribed to the use of closely spaced furrows, which allow a rather uniform water application. Citrus groves where the water is, on the other hand, restricted to comparatively "narrow bays" were found to be very subject to salt accumulation. Deciduous trees could be placed between these two extremes both in the application of irrigation water and the liability to salt damage.

An interesting method, practised in some orchards of the surveyed area consisted in watering two broad furrows close to the tree rows so as to concentrate the salts in the bay; this reduced the damage to trees appreciably.

Although the effect of differences in irrigation methods are very important it is obvious that salt tolerance is a factor that should not be underrated.

(iii) *Flood irrigation and crops grown*—Flood irrigated pastures have been successfully established during winter, when salt concentrations in the surface are fairly low, on heavily salted land. Salty patches on this land do not return as long as it is kept under pasture. The absence of obvious salt damage on shallow rooted pasture species is mainly due to the flood irrigation method. This was indicated by serious salt accumulation in land not properly graded and by the difficulties encountered in establishing pastures in salty, well-developed depressions. Again the tolerance of some grass species may be a contributing factor.

An interesting effect of cover crops on salt accumulation was observed during the Survey. When deep-rooted cover crops are sown in furrow irrigated orchards that are salt affected, salt damage to the trees is reduced considerably and surface salt crusts disappear. Salt damage does not return as long as the cover crops are present. The salts are apparently leached from the surface layers. Magistad and Christiansen (1944) discussing the salt tolerance of lucerne assumed that the deep-rooted system of this plant was the primary factor in its salt tolerance, since it allowed an evasion from the high salt concentration in the surface layers. De Sigmond (1927) describes, under American conditions, a situation very similar to that found in the M.I.A., and he assumed that this salt distribution was due to the utilization of water at lower depth thus preventing capillary rise to the surface. The leaching of salts from the surface layers in the M.I.A. is evidently due to the lowering of the watertable and drying out of the soil to an appreciable depth. West (1933) has described the occurrence of both phenomena in the M.I.A. when lucerne was grown.

Wagner (unpublished data, 1947) showed what use can be made from a combination of cover crops and flood irrigation. Half of an orchard was planted to lucerne and irrigated with the border check method. The other half was furrow irrigated. The orchard was sampled yearly, over a six year period. The salt distribution with depth is shown in Figure 3. It is apparent that approximately three times as much salt is present in the surface of the soils in the portion not planted with lucerne, as compared with that carrying a stand of this crop, and that the salt distribution under lucerne is similar to that of a virgin soil.

Discussion

(a) *The effect of geological layers*—Taylor and Hooper (1938) and van Dijk (personal communication, 1956) have shown that the soils of the Mirrool Area have been formed on different geological layers. The results of this Survey indicate that occurrence of salty soils can be adequately described in terms of topo-

graphy, soil texture and structure, and land-use. The only two important geological features are sandbeds which, if not saturated, have prevented salt accumulation almost completely, and the heavy blue clay occurring at depths of 11 ft or deeper described by Taylor and Hooper (1938). This layer is the primary cause of the formation of high watertables. Geological layers may be of much greater importance in areas where the salt contents of such layers differ markedly. This influence would also be expected to be greater when deeper soil layers would have a more permeable nature, which would cause a general salinity pattern. In the Mirrool Area the fairly impermeable nature of the deeper soil layers gives rise to a much more localised salinity pattern.

(b) *Effect of irrigation methods* — Kelley (1951) states that in California more salt is leached from the upper 6 ft of the soil under furrow irrigation than under flood irrigation. He emphasizes that this is not contradictory to the fact that irrigation methods which give an even water distribution are superior to furrow irrigation in establishing a more favourable distribution in the surface of the soils. The lack of accurate measurements of the amount of water applied and of previous records on soil salinity, made it impracticable to obtain information of this nature for the Mirrool Area. The majority of the soils in the Mirrool Area became fairly impermeable at depths between 5 and 6 ft. Under these conditions different irrigation methods would not be expected to cause differences in leaching of the first 6 ft. Because large areas of only slightly saline soils occur and the irrigation water is of a high quality differences in salt distribution due to different irrigation methods are, on the other hand, of great importance.

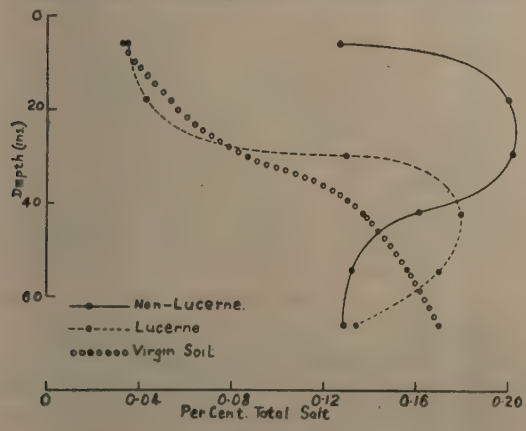

Figure 3.
Salt distribution with depth on a virgin soil, on a furrow irrigated soil without lucerne and a flood irrigated soil with lucerne.
(Unpublished data, Wagner 1947.)

(c) *Salinity hazards in the Mirrool Area*—The salt liability of the soils of the District can thus be summarized in Table II.

TABLE II.
Salt liability of M.I.A. soils.

Salinity Hazard	Soils and Topography
None	Colluvial soils of higher elevation Highest spots of sandhills
Weak	Impermeable soils under flat topography
Medium	Impermeable soils in depressions, drainage ways and brake of slopes, permeable soils under flat topography
High	Permeable soils in weak depressions, drainage ways and break of slopes.
Very high	See high, where soil layers below 5 ft remain permeable

It can be concluded that the general conditions in the Mirrool Area are not particularly conducive to salt accumulation. The salt damage is as a rule confined to furrow irrigated, salt sensitive, horticultural and vegetable crops. Another form of land-use with more salt resistant crops and different irrigation methods would reduce the salt problem greatly; partly by reducing the possibilities of salt accumulation and partly because the relatively small areas affected seriously are mainly of importance in intensive agriculture.

Acknowledgements

The author is indebted to Mr. E. S. West, formerly Officer-in-Charge, Irrigation Research Station, C.S.I.R.O., Griffith, for useful criticism and assistance in the writing of the manuscript.

Thanks are also due to Mr. D. L. Jackson, Lecturer in Agricultural Botany, Sydney University, Mr. K. Spencer, Research Officer, Regional Pastoral Laboratory, C.S.I.R.O., Armidale, and Mr. V. J. Wagner, Senior Agronomist, Department of Agriculture and Stock, Brisbane, for permission to quote their unpublished data.

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(*Received for publication, June* 26, 1957.)

BOOK REVIEWS

PROCEEDINGS OF THE AUSTRALIAN SOCIETY OF ANIMAL PRODUCTION

VOLUME I

(*Available from The Australian Institute of Agricultural Science, 226 Clarendon St., East Melbourne, C.2., Victoria—£1 per copy*)

The publication of the first volume of the Proceedings of the Australian Society of Animal Production is an event of considerable importance. This Society was formed in 1954 with the object of furthering the interests of the ever increasing number of workers in the diversified fields of animal husbandry. The first Biennial Conference of the Society was held at Armidale in 1956 and it is the proceedings of this meeting which are recorded in the present volume.

From its inception, the Society has tried to attract members from all branches of the animal industries and its range of activity has been correspondingly wide.

This diversification of interests is reflected in the contents of this volume. Twenty-eight papers are recorded, covering various aspects of nutrition, breeding, genetics and management. The subject of pasture utilization is touched on in a number of contributions, and ways of improving the efficiency of producing wool and meat is a theme running through them all.

This breadth of cover, however, has brought with it its own difficulties. Inevitably the quality of the contributions is variable and there is no uniformity in the way in which papers are presented. Some contributions occupy only a few paragraphs, others several pages. Some report original work, others are written as popular essays. Future volumes will probably see a greater degree of uniformity imposed upon both style and content.

There is no doubt, however, that this, and subsequent volumes, will join with the publications of the Societies of Animal Production of New Zealand, Britain, and America to form a valuable source of information and reference for all those interested in animal husbandry.

D. E. TRIBE.

TECHNICAL NOTES

THE EFFECT OF SOD-SEEDING CLOVERS ON THE PRODUCTIVITY OF A PASPALUM PASTURE IN THE RICHMOND RIVER DISTRICT OF N.S.W.

An overseeding implement, designed primarily for the purpose of sowing pasture legumes directly into nitrogen deficient paspalum (*Paspalum dilatatum*) swards in the Richmond River district of northern N.S.W. was previously described by Breakwell and Jenkins (1953).

Since 1952 large numbers of commercial sod-seeders, modelled on the prototype described, have been used for the establishment of improved pastures on the coast and tablelands of N.S.W.

From April 1953 to May 1955, studies were made on a Krasnozen soil (Wollongbar clay loam, Nicolls *et al.* 1953) in the Richmond Region to determine the effect of a sod-seeded clover pasture on nitrogen status. The results of this study will be reported later.

In the course of these investigations, three one yard square pasture samples were collected every month from an ungrazed unimproved paspalum pasture and an adjacent ungrazed paspalum pasture which had been sod-seeded to a mixture of pasture legumes. The dry matter and protein content of the clover and grass in each sample was determined.

The mean values of the determinations for the three samples from each pasture provided an unbiased estimate of the effect of sod-seeding on the dry matter and protein production of an ungrazed paspalum pasture throughout the period from May 1953, to May 1955.

Experimental

The paspalum pasture, on the property of Mr. J. Corcoran, Wollongbar near Lismore, was sod-seeded to a mixture of 6 lb of subterranean clover, *Trifolium subterraneum* (containing 1½ lb of each of the strains Yarloop, Clare, Bacchus Marsh and Mount Barker), 3 lb of crimson clover, *Trifolium incarnatum* and 2 lb of red clover, *Trifolium pratense* per acre on 12th March 1953.

Each type of leguminous seed was inoculated with an efficient strain of rhizobium and the mixed seed was banded with a fertiliser mixture, prepared one month before, which provided molybdenised superphosphate and dolomite each at 2 cwt per acre. The sod-seeding drills were 7 in. apart and the seed was planted at an average depth of one inch. The well structured red soil was moist at planting time and crumbled into the furrow after the sod-seeding shoe passed, covering the seed and fertiliser layer with about one-half inch of soil.

In March 1954, the sod-seeded area received a further dressing of superphosphate at 2 cwt per acre.

The unimproved paspalum pasture adjoined the sod-seeded pasture. This received no treatment and the samples taken from it corresponded to samples taken from the sod-seeded pasture on each sampling occasion.

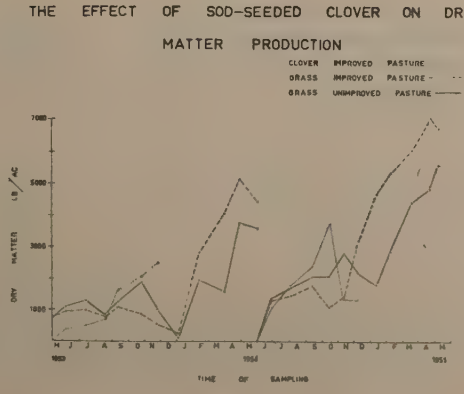
THE EFFECT OF SOD-SEEDED CLOVER ON DRY MATTER PRODUCTION
CLOVER IMPROVED PASTURE
GRASS IMPROVED PASTURE
GRASS UNIMPROVED PASTURE
DRY MATTER LB/AC
7000
5000
3000
1000
M J J A S O N D J F M A M J J A S O N D J F M A M
1953
1954
1955
TIME OF SAMPLING

Figure 1.

Results

The results obtained are shown in Figures 1 and 2 and these are further summarised in Figures 3 and 4.

At the peak of the spring production in November 1953, a dry year, the dry matter yield per acre of the sod-seeded pasture was estimated at 2,987 lb, while that of the unimproved was 990 lb. At the same time the protein yield per acre of the former was estimated at 370 lb while that of the latter was only 48 lb.

The presence of legumes during the winter and spring increased the summer production of paspalum, giving summer paspalum yields in April, 1954, of 5,116 lb on the sod-seeded pasture compared with 3,724 lb on the unimproved. At the same time the respective yields of crude protein per acre were 235 and 153 lbs.

During the 1954/55 season the effects of sod-seeded clovers on production was more marked, largely due to more favourable growing conditions. At the peak of the spring production in October, the sod-seeded area yielded 4,737 lb of dry matter and 660 lb of crude protein compared with 2,012 lb dry matter and 142 lb crude protein for the untreated paspalum pasture.

The peak summer production of paspalum was 7,004 lb of dry matter and 294 lb of crude protein for the sod-seeded area and 5,593 lb and 267 lb respectively for the unimproved pasture.

Discussion

The data from this experiment would suggest that the effect of sod-seeding clovers in this particular case has been to increase total dry matter production by 3,390 lb or 72% and crude protein production by 404 lb or 205% in the first year. This increase was due mainly to the subterranean and crimson clover, the red clover contributing only in the late spring period.

In the second year, the increases of 4,136 lb of dry matter or 54%, and 445 lb of crude protein, or 109%, were due almost entirely to the regenerated subterranean clover.

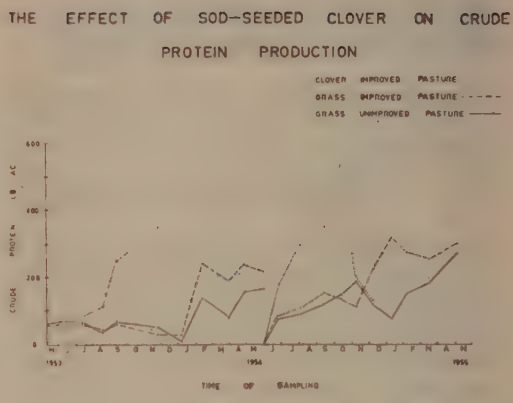
THE EFFECT OF SOD-SEEDED CLOVER ON CRUDE PROTEIN PRODUCTION
CLOVER IMPROVED PASTURE
GRASS IMPROVED PASTURE
GRASS UNIMPROVED PASTURE
CRUDE PROTEIN LB/AC
TIME OF SAMPLING

Figure 2.

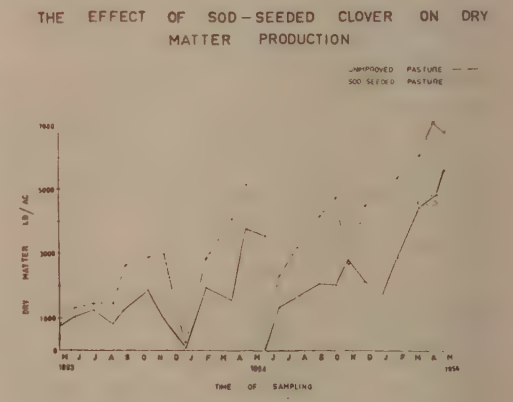
THE EFFECT OF SOD-SEEDED CLOVER ON DRY MATTER PRODUCTION
UNIMPROVED PASTURE
SOD SEEDED PASTURE
DRY MATTER LB/AC
TIME OF SAMPLING

Figure 3.

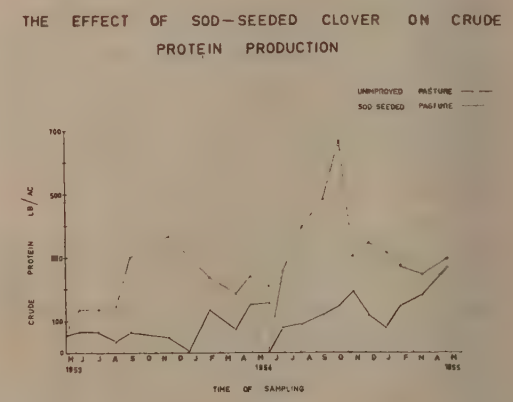
THE EFFECT OF SOD-SEEDED CLOVER ON CRUDE PROTEIN PRODUCTION
UNIMPROVED PASTURE
SOD SEEDED PASTURE
CRUDE PROTEIN LB/AC
TIME OF SAMPLING

Figure 4.

On the basis of this data, it would appear that the production of the unimproved paspalum pastures could be greatly increased by sod-seeding clovers provided that the subterranean clovers can be maintained in the sward.

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(*Received for publication, May* 25, 1957.)

THE EFFECT OF IRRIGATED PASTURE IN THE RICE ROTATION ON SEED POPULATIONS OF *ECHINOCHLOA CRUS-PAVONIS*

Introduction

Weed competition at the seedling stage has reduced yields in the irrigated ricefields of the Tullakool district, New South Wales. *Echinochloa crus-pavonis* (H.B.K.) Schult* is one species causing heavy loss. It is limited to parts of the Tullakool district under rice in the 1943-45 period. *E. crus-pavonis* grows and matures with the rice, and cannot be controlled by flooding. Some growers drain the irrigation bays after the rice and weed seedlings emerge. Then the bays are harrowed vigorously, or are grazed by large flocks of sheep. These treatments are supposed to check the growth of the weed plants which even at this early stage are taller than the rice seedlings. Unfortunately both treatments damage the young rice plants.

Recently, good rice crops have been grown on land which had previously carried dense populations of *E. crus-pavonis* in 1945. In the intervening period an irrigated pasture of subterranean clover and Wimmera ryegrass occupied the ground. This suggested that the introduction of irrigated pasture into the rice rotation had reduced the number of viable weed seeds in the soil.

The results of a germination experiment designed to measure the seed burden of *E. crus-pavonis* in fields with different cropping histories are reported here.

Method

In November, 1953, three adjoining paddocks which were known to have carried dense communities of *E. crus-pavonis* in 1946 were sampled. The cropping history of these areas was the same until 1948. The full treatments are set out in Table I.

Five random samples, each 12 in. x 9 in., were selected in 0.25 acre of each paddock. All *E. crus-pavonis* seedlings were counted and removed. The 0-1.5 in. and 1.5-3.0 in. depths were placed separately into flats with an internal dimension of 12 in. x 9 in. and transported to the laboratory where the soil was saturated with water. After one month the seedlings were identified and counted.

Results and Discussion

The results are set out in Table II. Two species, *E. crus-pavonis* and an *Eleocharis* spp. (probably *E. pallens* (Benth.) S.T. Blake) grew on the saturated flats. As this *Eleocharis* sp. is normally killed by ploughing and dry fallow prior to sowing, the counts of this species are not presented. With good farm management it is seldom a problem.

**E. crus-pavonis* appears to be the species described by Robbins, Crafts and Raynor (1948, p. 418) as 'White water grass'.

TABLE I.

Cropping history, 1945-53.

Area 1, 2 and 3.			
1945	Rice sown (October) Heavy *E. crus-pavonis* infestation		
1946	Rice harvested (April)		
1947	"Volunteer" pasture		
	Area 1	Area 2	Area 3
1948	Subterranean clover-Wimmera ryegrass pasture sown (Autumn)	Rice sown (October) Heavy *E. crus-pavonis* infestation	Subterranean clover-Wimmera ryegrass pasture sown (Autumn)
1949	Irrigated pasture	Rice harvested (April)	Irrigated pasture
1950	„ „	"Volunteer" pasture	„ „
1951	„ „	„ „	„ „
1952	„ „	Wheat (April-December)	Rice sown (October) Almost weed-free, 300 plants/acre
1953	„ „	"Volunteer" pasture	Rice harvested (April) Heavy *E. crus-pavonis* germination (November)

In November no *E. crus-pavonis* plants were growing in the six-year-old pasture on Area No. 1, and no plants germinated in the soil samples from this treatment. No pasture had been sown in Area 2, and the plant community in 1953 consisted of scattered herbs. Most of the soil surface was bare, and small depressions were inhabited by *Echinochloa* spp. In the laboratory, inundation gave a potential two million seedlings per acre. This would be sufficient to cause a crop failure. Following four years of irrigated pasture the rice crop from Area 3 yielded heavily. There were a few weed plants in the crop (300/acre). Seven months later, seed from these plants germinated with rainfall and gave the results set out in Table II. Counts of seed on representative *E. crus-pavonis* plants in a rice crop vary from 60,000 to 100,000 per plant. Germination tests at the Regional Pastoral Laboratory, Deniliquin, show that 97 per cent. of seed is viable and germinates in three days at 35°C.

TABLE II.

*Viable seed populations of E. crus-pavonis as at November, 1953**
(*per* 100 *in.*^{2} *of soil surface*).

Depth (in.)	Area 1	Area 2	Area 3
0-1.5	0	31 ± 6	414±106
1.5-3.0	0	16 ± 5	15± 8

*Field germination November, 1953, and laboratory germination December, 1953.

From these observations it is not possible to tell whether the additional two

seasons of irrigated pasture on Area 1 have eliminated the residual seeds, or whether the ratio of sampled to total area of 1:25,000 is too large to pick up the 300-500 seeds per acre that one could reasonably expect on the basis of the Area 1 results. It is also doubtful if the fertility effect of the irrigated pasture discriminates against *E. crus-pavonis* since the success or failure of a rice crop is apparent at the seedling stage.

These results suggest that four or five years of irrigated subterranean clover and Wimmera ryegrass will reduce the number of viable weed seeds in the soil. The few remaining seeds that are viable are not enough to affect rice seedlings. The results for Area 3 show that in the course of one rice crop the few plants of *E. crus-pavonis* that do grow from this small supply of seed are able to build up a substantial seed reserve in the soil. The results from Area 2 could indicate that a more vigorous community than scattered herbs or a wheat crop is needed to compete with, and eliminate *Echinochloa* spp.

In the field *E. crus-pavonis* germinates readily in saturated soils from mid-October onwards. This is the period when the irrigated pasture of subterranean clover and Wimmera ryegrass is growing strongly. Clearly these conditions do not favour the germination of *E. crus-pavonis*, and so a pasture of this type should be a more efficient means of control than a summer pasture.

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(*Received for publication, September* 3, 1957).

A METHOD OF MEASURING THE EVAPORATION LOSS FROM SPRINKLERS

Irrigators tend to think that the evaporation losses which occur during spray irrigation are important and the work of Christiansen (1942), Mather (1950) and Frost and Schwalen (1955) indicates that under extreme conditions this is so.

The total loss which occurs is the sum of the evaporation while the spray is in the air, and of the evaporation from the wetted foliage and from the soil surface. Probably the loss of water which occurs from the time the water leaves the sprinkler nozzle to when it reaches the ground is a small proportion of the total loss.

A method of measuring this loss has been devised. It is estimated from the increased chloride concentration of the water collected where the spray reaches the ground over that of the water as it leaves the sprinkler. The increase in concentration is due to an equivalent loss of water.

The water used contains 1,550 p.p.m. of total soluble salts (from conductivity) and 620 p.p.m. of chloride which gives a titre of about 15.50 mls. for a 25 ml. aliquot using N/35.5 silver nitrate. A difference of 0.05 ml. in the titre of before and after samples is equivalent to 0.3 per cent. loss.

The method is therefore extremely sensitive but it has been used only to measure the loss from the furthest thrown large drops from a single nozzle of an isolated sprinkler and therefore not the losses which occur in the field.

The following results (Table I) were obtained with a $\frac{1}{4}$ in. nozzle at 30 lb/sq.in.

TABLE I.

Air Temp. °F.	Relative Humidity %	Wind Veloc. m.p.h.	Measured Evaporation loss %	Evaporation loss (Frost and Schwalen)
85	46	1.5	1.84	2.0
87	32	1.5	1.94	2.3
88	20	0.5	1.56	2.5
80	29	3	2.05	2.7
62	64	0	0.62	0.8
67	49	1.5	2.76	1.5
72	38	2	1.66	1.8
76	34	1.5	1.84	1.9
76	59	1.0	0.41	1.2
43	92	0	0	

and these are compared with those of Frost and Schwalen for similar conditions.

The agreement between the two methods of estimation is fair.

These results confirm the order of magnitude of Frost and Schwalen's results but are even further than theirs from Christiansen's who, under similar conditions to these (rapid catch of peripheral drops) places the loss in air as being less than 2 per cent. even under very extreme conditions.

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(*Received for publication, August* 10, 1957.)

SOME FLUCTUATIONS WITHIN RABBIT POPULATIONS IN WESTERN AUSTRALIA

During the period between October 1953 and September 1955, two myxomatosis attendants, one operating at Darkan and the other working in the Wongan Hills, Bridgetown, Kojonup, Cranbrook, Mt. Barker and Albany areas kept a constant check on their daily catch of rabbits for the purposes of obtaining the sex ratio of all adult rabbits caught and determining the fraction of juveniles.

The records kept at Darkan embrace the period from October 1953 to April 1954, whilst the others include the periods November 1953 to February 1954 and from June 1954 to September 1955. It is unfortunate that no records are available for the month of May 1954.

Altogether, 5,080 rabbits were handled by these two operators in the 27 man-months of their employment, giving an average catch of 188 per man-month. With the exception of a few records, all rabbits were obtained in the wetter portions of Western Australia in the 25-40

in. rainfall region of the lower south west and the lower great southern regions. The method of capture in all cases was by the use of ferrets and nets.

Sex Ratio

Taken over the entire period, 1,116 adult males and 2,171 adult females were captured. This gives a ratio of 51.4 males for every 100 females. It must be borne in mind that these figures merely represent the sex ratio of rabbits caught by means of ferrets, which is almost certainly not a natural sex ratio. Thus, several factors may influence the result. Excessive heat may tend to make rabbits reluctant to leave burrows and, also, females with young are probably hard to chase out. Large vigorous rabbits, particularly bucks, would no doubt be difficult for the ferrets to eject from warrens and the size and complexity of the warren structure would also add to the ferret's difficulty. In this respect it is of importance that the attendants did not work the very large warrens. Also ferrets vary considerably in their working ability.

The pattern of the graph (Figure 1) confirms what is an expected thing by some ferretters, i.e. that more females than males are caught by this method. The ratio in this case is approximately two females to one male. During the latter part of 1953, the sex ratio remained constant at approximately 48 per cent. , but in January and February 1954, it fell away rapidly until February when less than half as many bucks were being caught. March and April 1954 showed a marked increase in percentage, followed by a fall in June and July. The percentage recovered again in August and remained

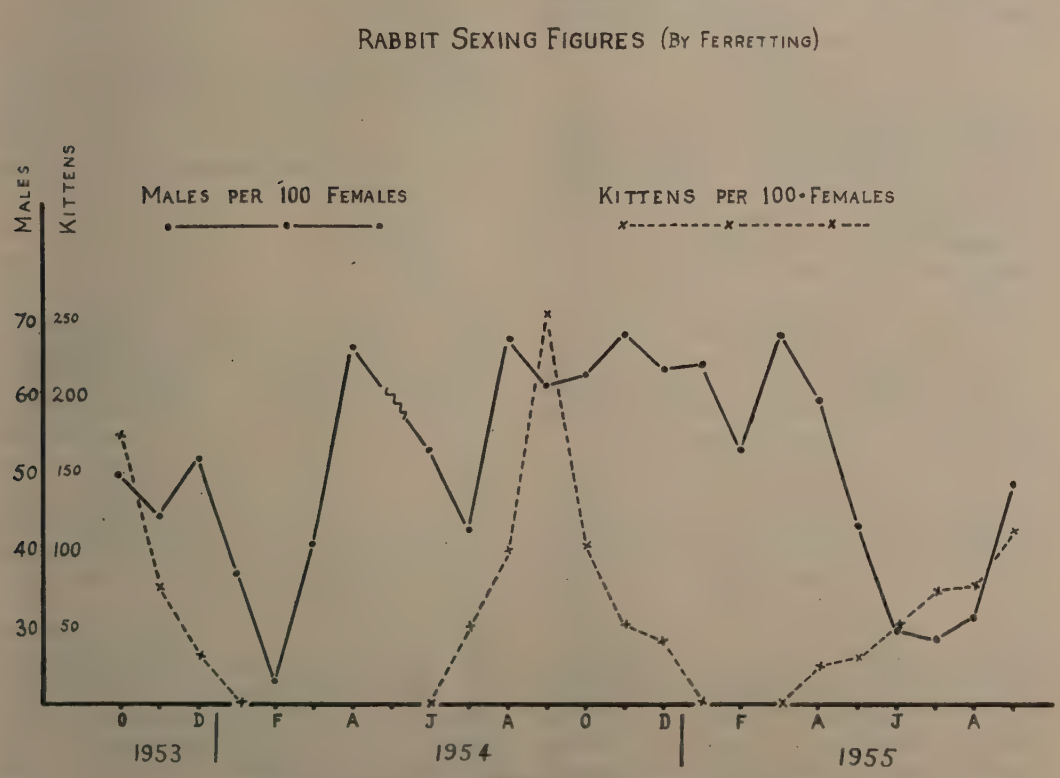

Figure 1.
Average monthly ratios of all rabbits caught by attendants.

remarkably constant until January 1955 when another fall started. However, this was arrested in mid and late February 1955 which coincided with unusually heavy and unseasonable rains which fell at that time. Another peak was reached in March 1955 (60.3 per cent.) and then a steady decline set in until June, July and August, when ratios in the region of 30 per cent. were obtained.

Two things stand out from the graph of sex ratios. They are:—

(1) A decline in the percentage of males in the hot summer months—January and February.
(2) Another decline in mid winter—centred on July.

Taking into account the various likely factors involved, the troughs occurring in mid summer could be due to a lower ratio of males in the warrens or a greater difficulty in driving the larger and stronger males from the warrens into the hot environment above ground.

As there is no breeding at this time of the year, this factor is of no importance. It will be noted that the trough occurring in the summer of 1954 was approximately two months longer than in 1955. This, as mentioned before, coincided with the unseasonable heavy rain which fell in February and was probably due to factors related to unseasonable breeding caused by the rains. (See below.)

With the winter troughs, the position is more complex and is probably related to the wet conditions prevailing in some warrens, to the breeding conditions of the does, and also possibly, to the presence of the kittens in the warrens. It would appear from the graph that the wet seasonal conditions of 1955 caused a much more rapid fall in the male percentage. On the other hand, if the females which are then at the peak of the breeding season, readily vacate the warrens in an effort to draw the ferret away from the young then a similar effect will be obtained. It seems more likely however that fewer males are inhabiting the warrens and that they are probably living above ground. The presence of the kittens themselves in the burrow may have an effect on the males' choice of living place.

Kittens and Sub-Adults

All the obviously immature rabbits were arbitrarily divided into kittens and sub-adults (half grown). This was done in an effort to obtain a fairly clear cut indication of the commencement and finish of the breeding season. In both 1954 and 1955, kittens were recorded one month before sub-adults and in both instances, sub-adults were reported for two months after kittens had ceased to appear.

In 1954, the first kittens were obtained in July. At this time the operator was working in the Boyup Brook area. Rainfall data for this town in preceding months was as follows:

February	12	points
March	20	„
April	86	„
May	310	„
June	309	„

In 1955, kittens first appeared at the Mt. Many Peaks area in April. At the closest weather station to this area (Albany, approximately 20 miles away) rainfall for the months preceding this was as follows:

January	96	points
February	635	„
March	42	„
April	559	„

Following the unusually heavy rains which occurred in mid February, rabbit breeding commenced in most parts of the state and kittens were captured in April, exactly two months after the rains. As kittens are reported to leave the warrens at three weeks of age (Southern 1940), following a gestation period of four weeks, it seems obvious that breeding must have started immediately following the rains. This is borne out by an observation made at Dowerin where young kittens were also observed barely two months after the February rains. In this area, the following rains had not been sufficient to sustain plant growth (only 9 points in March) and at the time of the visit all green feed had dried off. It would thus appear that the onset of breeding is "triggered" rather

by the rains themselves than by any change in the nutritional status of the available feed. The earlier start of the breeding season in 1955 was undoubtedly due to these early rains which fell in mid February. Following the opening rains, most of the area over which the operator was working underwent a period of comparative dryness in March. This is reflected in the rather slow nature of the kitten build-up in 1955 as compared with the previous year. However, by July and August, approximately the same conditions as the previous year applied, but the September peak for 1955 was far less than in 1954. This is possibly due to the excessively wet winter of 1955 in which numerous reports of rabbits drowning in the burrows were received.

Conclusion

The graph gives some indication of the mating and breeding season of the rabbit in Western Australia as deduced from samples taken by ferretting. However, one point which has not been mentioned previously is the reliability of the ferret in this work. It has not been an accepted practice, especially in England, to use ferrets after the breeding season has commenced. It is not recommended for several reasons (R. Sharpe 1918). "When the bucks begin to breed, they become 'rank' and this is said to be objectionable to the ferrets. They may however, work while stimulated by hunger. It is known also that does will, at this season, take refuge in blind ends of holes and for this reason the ferret encounters the male first and drives him to the same blind end. The ferret will probably leave them both through the natural disinclination to tackle the buck while he is rank. It must also be pointed out that at this time of the year, ferrets will undoubtedly work the smaller rabbits in preference to the adults and so tend to give a higher percentage of kittens and sub-adults than is actually the case".

However, in spite of the limitations of the ferretting method, the figures do provide some interesting ideas and shed some light on the breeding season of the rabbit in Western Australia.

Acknowledgements

Appreciation is expressed to Mr. J. H. Calaby of the C.S.I.R.O. (Wild Life Survey Section) for much help in preparing this paper and to S. Ball and C. Hadley for their untiring work in the field.

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(*Received for publication, May* 27, 1957).

BULLAMON LUCERNE (*PSORALEA ERIANTHA* BENTH.) —A PLANT WORTH WATCHING

During the past four years, this legume has shown remarkable growth and persistence on the alluvial sandy loams of the Warrego river channel levees just north of Charleville. A grazier has carried cattle at the rate of two beasts to the acre for a period of up to nine months and only shut the paddock to allow a nearby crop of oats to develop. By mowing the associated natural *Aristida* species, the legume has been encouraged and is spreading rapidly through this belt of country. Seedlings are also appearing in a cultivation area sown to Western Aus-

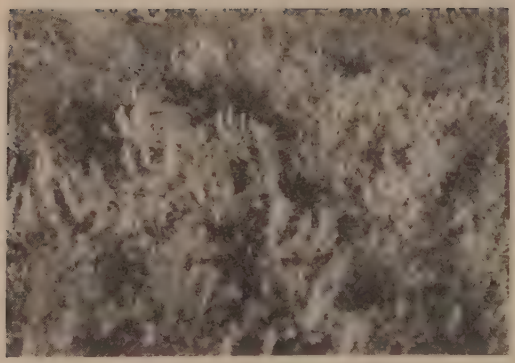

Figure 1.
Bullamon Lucerne in flower—Charleville, April, 1957.

tralian buffel grass (*Cenchrus ciliaris*) and a very fine pasture is developing. The young plants are effectively nodulated.

Bullamon lucerne is a local name arising out of the fact that several years ago plants were discovered thriving on Bullamon Plains, a property near Thallon some thirty miles from Mungindi on the N.S.W. border. Guilfoyle calls it "Woolly-flowered Scurfy Pea", a somewhat lengthy but descriptive name. It is found in all of the mainland Australian States, but chiefly in the Murray-Darling system.

The plant has the following botanical description: Perennial, soft white tomentum all over; leaflets mostly ovate, broadly cuneate at base, generally 2-3 cm long, toothed; flowers purplish, in long rather dense spikes, the naked part of the stout peduncle shorter than the leaf: calyx white, villous, about 8 mm long, the lowest tooth considerably longer than the others; petals slightly exceeding calyx; pod tomentose.

The ripe pod drops to the ground under the trailing stems and seed harvesting would have to be performed by suction. Cutting the whole plant, drying and threshing yields only a very small proportion of ripe seed. Crimson wing parrots (*Aprosmictus erythropterus*) and galahs (*Kakatoe rosei-capilla*) harvest much seed.

An analysis of a composite sample, including trailing stems and leaves collected at the end of April, 1957, and air dried, is given in Table I.

TABLE I.

Percentage composition of Bullamon Lucerne.

Moisture	9.6
Protein	15.4
Fat	3.8
Fibre	27.6
Carbohydrates	35.6
Ash	8.0
Lime (CaO)	1.3
Phosphoric Acid (P_2O_5)	0.41

On a dry-matter basis, the protein content is 17.0 per cent.

At Charleville (26°25′S, 146°13′E, and at an elevation of 965′ above sea level), growth persists all the year round.

This perennial is remarkably deep-rooted, the main tap root being found to be still half an inch thick at a depth of 5 ft. The habit of growth and its root system can be seen from Figures 1 and 2.

It is thought that its prominence over recent years in this area has been associated with the wane of the rabbit population following the spread of myxomatosis. In this deep sandy levee soil, rabbit war-

Figure 2.
The well-developed tap-root of Bullamon Lucerne.

rens were numerous, and the plant itself and possibly the roots were extremely palatable to them.

On Western sandy levee soils, this plant would seem to have a future. Experiments are in hand to try to widen its distribution. These levee soils have a reasonably high available phosphate content of about 90 p.p.m., and this factor may determine its spread.

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(Received for publication, September 21, 1957.)

A SOURCE OF ERROR IN POT EXPERIMENTS WITH SULPHUR

In a recent experiment in which glazed pots of one kilogram capacity were used, considerable variation in plant growth was observed within the treatments receiving no sulphur. Yields varied from 0.12 g to 7.62 g (Figure 1). On many pots the glazing was found to be "crazed" and examination suggested that the worse the glazing the better the plant growth. Accordingly, when the plants had been harvested, the pots were filled with water and soaked for three days. The water absorbed was taken as a measure of the degree of deterioration of the glazing and was found to vary from 1 g to as much as 120 g. Correlations between plant growth without applied sulphur and water absorption by the pots were found to be as high as +0.85 but with applied sulphur the correlations were very low. Subsequent examination showed that several badly glazed pots contained considerable quantities of sulphur which diffused slowly into water standing in the pots.

Figure 1.

Duplicate pots planted with perennial ryegrass and receiving no added sulphur. The left hand pot is badly glazed.

Since most of the pots had been previously used several times, it was difficult to determine how much of their sulphur content was originally present and how much had been absorbed during previous experiments. When two badly glazed pots were pulverised for sulphur determination, one which was apparently unused contained almost no sulphate whereas one recently used for a plus sulphur treatment contained about 40 mg of sulphate sulphur. This would indicate that most of the sulphur in this line of pots was derived from absorption during previous experiments.

Most of the well glazed pots used in the experiment were derived from a different line of pots. Two pots of this batch, one recently used for a plus sulphur treatment the other recently used for a minus sulphur treatment, were both found to contain about 10 mg of sulphate sulphur. It therefore seems likely that in this case the sulphur was originally present in the

pot and this could become a contaminant if the glazing deteriorated.

In plant nutrition experiments with major elements it is not usual to take precautions to prevent contamination from the pot. It is clear that in work with sulphur such precautions are necessary and in future work at this laboratory it it intended to use polythene bags to line the pots.

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(*Received for publication, October* 23, 1957.)

TIME OF HARVEST IN RELATION TO GRAIN-BREAKAGE ON MILLING IN RICE

Summary

Studies on the relation between time of harvest and breakage on milling were undertaken at the Kimberley Research Station during the 1955-56 summer rainfall season.

The results indicate with both a long grain and a short grain variety, that delayed harvesting leads to increased breakage on milling.

Rice differs from other cereal crops in that the grains are normally cooked whole and are not first ground into flour. Consumer preference demands whole grain rather than broken grains, and a considerable premium will be paid for whole grain. Some idea of the importance of whole grain may be gained from a statement by Thompson *et al.* (1955) that an increase of one pound in the production of whole grain ("head") rice above the base value of 48 lb per hundred pounds of paddy rice would have increased Californian production for 1953 by 12,000 cwt valued at 240,000 dollars.

It is well known that much of the grain breakage during harvesting or milling results from fine crosswise cracks that have developed in the grain during the ripening process. "During most seasons in practically all rice crops a surprisingly high percentage of grains show a fine crack (crosswise), but only with unsuitable conditions does the grain actually break, either during shipping or milling operations". (N.S.W. Dept, Agric. 1953).

It is also well established that this cracking or checking, which is commonly referred to as sunchecking, results from rapid fluctuations in atmospheric humidity during the ripening process and there are various well recognized ways of avoiding trouble from this cause. In many tropical countries, the grain is parboiled (partially gelatinised) before milling, which effectively seals the cracked grains together. Alternatively, the crop may be cut with a binder some days before the grain is ripe, and the sheaves left to ripen in the field in such a manner that the grain is protected as much as possible from sun and rain (Jones *et al.* 1952). With modern methods of harvesting, in which the grain is stripped from the head in the field, it has been found desirable to strip the grain as soon as this can be done, and then to finish drying off the grain artificially (Jones *et al.* 1952). It has been found by experience that good mature grain can be obtained by harvesting when the moisture content is between 25 and 30 per cent. Harvesting earlier than this leads to the presence of immature chalky kernels in the crop, while the postponement of harvest until the grain moisture is appreciably lower may lead to much checking and subsequent breakage.

Rice has been grown at the Kimberley Research Station in Western Australia for some years, and in view of developing commercial interests in rice in Northern Australia it was felt desirable to pay some attention to harvesting and milling. Rice at Kimberley is grown in the con-

ventional manner, under flood conditions. It is sown in December with the commencement of the monsoonal rainy period and depending on the duration of the variety used, ripens early in the dry season. Most of the varieties grown at this time of the year have a duration period of 150-160 days. With planting in early December they are ready for harvest about the end of April or early May. At this time of the year, temperatures are still high with maxima around 95-100°F. and minima between 60 and 70°F. The days are mainly bright and sunny, with drying winds, but there may be occasional reversions to the wet overcast weather of the rainy season.

As the 1955-56 crop was nearing harvest, two bulk crops were selected for a harvest study. They were Shive-pu, a barley-like short grain variety, and Hnan-wa-phin-gauh, a long thin grained variety. The former has a grain length of about 5 mm with breadth rather more than half the length, whilst the latter has grains half as long again, but slightly narrower. Commencing at 28 days after the peak of flowering, samples were cut at intervals sufficient to provide 2 lb of seed on hand stripping. Small subsamples were taken immediately for determination of moisture content by drying to constant weight at 105°C., and the remainder hung up in a cool well-ventilated shed to dry out. At the end of the trial, when all samples had been reduced to a moisture content of about 12 per cent., they were shelled in a Smith pattern (Smith 1928) hand sheller and the percentage of whole and broken grains determined, using 1000 grain samples for each determination.

The results are shown in Table I. It will be noted that the moisture content of the grain fell steadily with advancing maturity at harvest down to a level of about 11 per cent. The proportion of whole grain recovered remained high in both varieties until low moisture levels were reached after which there was a rapid decline in whole grain recovery.

TABLE I.
Head yield from hand shelled samples.

Days from Flowering	Moisture Percentage at Harvest		Whole grain percentage on Shelling	
	Shive Pu	Hnan-wa-phin-gauh	Shive Pu	Hnan-wa-phin-gauh
28	20.8	26.2	99.0	99.4
29	19.9	25.5	97.2	96.1
30	18.2	25.6	83.1	93.3
31	17.2	22.3	83.9	91.2
32	17.8	23.1	84.2	92.8
33	16.6	21.8	83.7	89.8
35	16.2	16.7	82.0	89.0
37	16.0	15.5	81.1	77.6
39	11.8	13.0	78.2	61.9
42	11.6	11.5	52.0	41.0
45	11.1	11.3	41.0	40.0
58	11.1	—	40.3	—

Cutting of variety Shive Pu commenced on 7.v.56, and Hnan-wa-phin-gauh on 14.v.56.

These results are in accordance with the general principle that rice should be harvested as soon as possible and not left standing in the field to ripen, since this procedure leads to lower recoveries of whole grain rice. The hand operated Smith sheller used in these trials would be much less drastic in its effect than a power driven sheller, but even under these mild conditions recovery of the order of 100 per cent. whole grain was only obtained at the very early harvests.

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(*Received for publication, August* 1, 1957.)

A NOTE ON ALLEGED COOLER SUMMERS

One meets in various places the belief that summers are not as hot as they used to be, and the belief may be supported by figures. This note deals with the figures for two towns, Bendigo and Ballarat. Not only is the evidence for cooler summers in these towns shown to be worthless, but their worthlessness casts doubt on the value of other long-term records.

The official figures for the mean maxima in December, January and February (hereafter called the summer months) show that Ballarat was much hotter before 1890 than today, and that Bendigo was hotter before 1909 than today. The simplest way of examining these figures is to compare them with those of the same years for Melbourne, where the maxima of the summer months have fluctuated about a steady mean since records began. All three towns share in the same warm and cool spells, so the difference from Melbourne should vary less from year to year than does the local mean maximum. The calculations discussed here have been carried up to 1935, the last year of printed records.

TABLE I.

Difference in summer maximum temperatures between Melbourne and Ballarat.

Period	Ballarat minus Melbourne (Degrees)	Standard Deviation
1876-1889	+3.6	1.7
1891-1907	—0.3	1.3
1908-1921	—1.1	1.1
1921-1935	—2.6	1.0

(1) *Ballarat*—The figures are collected in Table I. They show three sharp breaks, as a result of which Ballarat finally appears as 6.2 degrees cooler relative to Melbourne than at the beginning. We are told (Bureau of Meteorology, 1937) that up till 1890 the temperatures were read by officers of the Lands and Survey Department, from 1891 to 1907 by the curator of the Botanic Gardens, and thereafter by Mr. Kennedy, initially at Darling Street. After each of these two changes of site the recorded maxima fell. There is a third sharp discontinuity in 1921, the origin of which is not revealed.

The standard deviation of these differences from Melbourne is commonly so low that a sudden relative change of only 1.5 degree stands out unmistakably. The pre-1890 figures, however, are much more erratic than the rest. They are also most improbable, since Ballarat is on the cool side of the Dividing Range and is 1,300 feet higher than Melbourne.

TABLE II.

Difference in summer maximum temperature between Melbourne and Bendigo.

Period	Bendigo minus Melbourne (Degrees)	Standard Deviation
1865-1876	+6.2	1.4
1876-1908	+9.1	1.3
1908-1935	+5.4	1.1

(2) *Bendigo*—The figures are collected in Table II, and illustrated in Figure 1. They show two sharp breaks, the first in 1876 and the second in 1908. The first may well correspond to the occasion when Mr. Taylor of the Lands Department re-

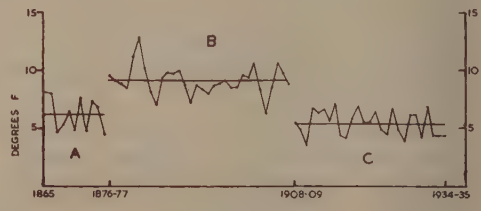

Figure 1.

Difference between summer maximum temperatures at Bendigo and Melbourne, under various observers at Bendigo. The break from A to B may coincide with the change from the Lands and Survey Department to the Sergeant of Police. The break from B to C coincides with the change from Sergeant Glenny to Mr. Beebe.

linquished his duties to the sergeant of police, for which no date has been recorded (Bureau of Meteorology, 1937). The second break is fully explained in the *Bendigo Advertiser* of 25 February, 1908. Mr. Glenny, sergeant of police, had been taking observations at Camp Hill. But officers of the newly-formed Commonwealth Bureau of Meteorology said that the instruments used "were not of the highest standard", and that the site was unsuitable. Mr. John Beebe was therefore appointed to replace Mr. Glenny in March, at a new site in East Bendigo, and more modern instruments were sent to Bendigo. At a later date, not earlier than 1914, the headmaster of Bendigo High School took over from Mr. Beebe, but this time there is no sign of a break. The successive years of the century show the following excesses for Bendigo: 9.4 (in 1900-1), then 10.6, 8.3, 6.3, 8.5, 10.6, 9.8, and 8.8; then comes the new site, with 5.5, 4.9, 3.5, 6.7, 6.4, 6.6, and 5.6.

This change in site has misled more than one calculator, using running means and not using the present method of differences (e.g., Deacon 1953; Anon 1957) into the belief that the climate of Bendigo has changed. The ten-year running mean of Bendigo's summer maxima is plotted in Figure 2 to illustrate how this additional computation has only masked the truth.

The standard deviations of Bendigo's summer maxima are 2.6 (before the change of site) and 1.9 (after the change), both far greater than those for the difference from Melbourne, as one should expect. The low standard deviation (1.3 degree) shown for the difference between Bendigo and Melbourne under the regime of the sergeant of police seems to pay tribute to his carefulness, if not to the design and location of his screen or to his instruments. However, the mean minimum temperatures for 1905, under the same regime, cause some concern. These, from February to October, are all about 10 degrees lower than those of any other year, and it is tempting to suggest that the minimum thermometer during these months was read from the wrong end of the indicator. Whatever the reason, these extraordinary figures are incorporated into the records, and might lead an incautious investigator to believe that the nights in Bendigo have been warming up.

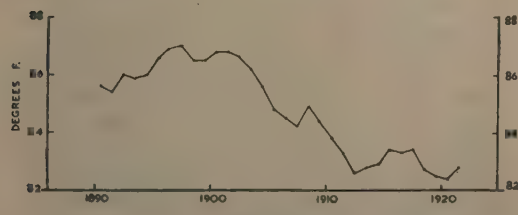

Figure 2.
Ten-year running mean of summer maximum temperatures at Bendigo. The true effect (see Figure 1) is obscured here by the smoothing and also by the use of the variable Bendigo maximum, rather than the difference between the maxima of Bendigo and Melbourne.

A further sharp downward change of one degree can be detected in Bendigo's readings from 1932. This might be related to either of two events noted in the archives, namely, the building of a new screen in 1930 or the installation of a new maximum thermometer in 1931. It is clear that such real hazards must outweigh any hypothetical changes in climate.

In past discussions of this theme, some people have hesitated to use Melbourne as a reference point because a big city is abnormal and may have an increasing trend in its temperatures relative to the rest of the State. When confronted with the steadiness of Melbourne's mean temperatures they can only say that Melbourne too would have been cooling off if it had not happened to be warming up at exactly the same rate. However, the changes referred to here are all sudden. If we explain our figures by inventing the hypothesis that Melbourne has been staying constant only through a relative warming up, it must follow that whenever a provincial city instals a new screen the temperature of the capital jumps a couple of degrees. But we need not even use Melbourne. Once the principle is discovered, we can study simply the differ-

ences between Ballarat and Bendigo. These show the same sharp breaks as those described, often more distinctly.

Victoria is unlikely to be the only State with such whimsical records. The simple method used here might have equally rewarding results elsewhere. For example, Bathurst during the summers of the 1870's was as hot as Dubbo (according to the published figures). But in 1878-9 there was a sudden change, and ever since then Bathurst has been about 8 degrees cooler. The year 1908 must be regarded with particular suspicion throughout Australia, as the year in which the Commonwealth Bureau of Meteorology took charge and replaced some of the observers.

We must sympathize with the authorities at the Bureau of Meteorology in their difficulties in collecting uniform and reliable figures through the country. They have inherited some questionable figures from earlier years, and at the best they have to rely on variable human beings. But they are aware of where to look for the best information, and they are cautious in discussions of changing climate, especially since the most controversial observations were made before the Bureau took control. I am grateful to officers of the Bureau for providing me with certain pieces of information from their archives.

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(*Received for publication, November* 6, 1957.)

WEIGHT RESPONSES TO TICK CONTROL AND PHOSPHATE SUPPLEMENTATION IN BEEF CATTLE AT KATHERINE, N.T.

Summary

Young Shorthorn steers on native pasture at Katherine, Northern Territory, have shown marked responses to tick control and to phosphate supplementation. Liveweight gains over a six-month summer rainfall period were increased by over 200 per cent. by tick control and by 35 per cent. with a phosphate supplement fed at fortnightly intervals.

In the course of cattle grazing experiments on native pasture at Katherine over the past two years, the provision of a phosphate supplement and the control of ticks (*Boophilus microplus* Canestrini) by regular spraying have been adopted as practical insurance measures against restricted liveweight gains and excessive losses, though no precise information on their effectiveness was available. Accordingly, an experiment designed to estimate the liveweight response of animals on native pasture to phosphate supplementation and tick control was initiated in November, 1956.

On November 30, sixteen 12-15 month old Shorthorn steers were weighed, divided into four groups of four matched for weight, and assigned at random to the following treatments:

Phosphate supp.) (Tick control
No supplement) (No tick control.

These steers were obtained from the Barkly Tableland area and were representative of stock carried by the better stations of the region. They were inoculated for pleuropneumonia and tick fever on transfer to Katherine.

The initial mean group weights were 512, 514, 515 and 516 lb per head. All sixteen were run as one herd in a 200-acre

TABLE I.

Main effects of phosphate supplementation and tick control.

Effect	Treatment	Liveweight gain from initial weight at Nov. 30 (lb/head).											
		Dec. 6	Dec. 20	Jan. 3	Jan. 17	Jan. 31	Feb. 14	Feb. 28	Mar. 14	Mar. 28	Apr. 11	Apr. 25	May 9	May 23
Effect of phosphate supplement. (Mean of spray and no spray)	Supplement	3	—5	24	32	36	59	71	74	71	76	98	84	100
	No supplement	—3	—10	15	17	27	39	44	48	39	45	60	51	74
	Difference	6	5	9	15	9	20	27*	26*	32*	31*	38*	33*	26
Effect of tick control (mean of supp. and no supplement)	Sprayed	Nil	—6	22	29	42	62	75	82	78	97	108	104	132
	Unsprayed	Nil	—9	17	20	21	36	40	40	32	24	50	31	42
	Difference	Nil	3	5	9	21*	26*	35*	42*	46*	73*	58*	73*	90*
Standard error of mean difference ±		5.8	8.6	6.4	10.0	9.8	10.0	12.1	10.4	9.2	13.2	13.4	14.2	18.9

*Difference significant at P = 0.05.

native pasture paddock composed largely of *Themeda australis, Chrysopogon fallax,* and *Sorghum plumosum.* Phosphate in the form of bone meal (13.6 per cent. P) was fed at fortnightly intervals while the animals were in the yards for weighing at the rate of 5 gm P per head per day, one-third of the total daily requirement. The tick control groups were sprayed with 0.5 per cent. W/V pp'-isomer D.D.T. at 4-weekly intervals until the end of January and thereafter fortnightly. Weighing was carried out at fortnightly intervals at 9 a.m. after 16 hours' starvation without water. The experiment was continued until the most favoured group began to show the normal dry-season fall in weight, the date being May 23, 1957.

There was no significant interaction between supplementation and spraying at any date of weighing, and main effects only are given in Table I. Some slight losses were recorded for the first four weeks, but from December 20 steady gains were made by all four groups. Significant differences in liveweight gain due to tick control were established by January 31. The mean difference between sprayed and unsprayed animals increased progressively from 21 lb per head on January 31 to 90 lb per head at the end of the trial, with a temporary drop at the end of April. A significant response to phosphate supplementation was not recorded until February 28. The difference between supplemented and unsupplemented animals remained more or less constant within the limits of error until the end of the trial, averaging 30 lb per head.

The experiment is being repeated in the 1957-58 wet season and a full account of both years' results will be presented at a later date.

M. J. T. NORMAN.

Division of Land Research and
Regional Survey,
C.S.I.R.O.,
Katherine, N.T.

(*Received for publication, August* 1, 1957.)

THESES

The Journal intends publishing from time to time short summaries of theses on which higher degrees in Agriculture have been awarded by Australian Universities. This will inform readers of the Journal of original research, details of which might not otherwise be published. If more information than is given in the summary is required, reference can be made to the original thesis at the respective University. It is hoped to publish summaries of all theses on which higher degrees were awarded in 1956 and in all subsequent years.

THE ROOT-NODULE BACTERIA OF PASTURE LEGUMES

The larger part of this thesis has been published separately. The following indicates the main topics dealt with and its method of arrangement.

The natural occurrence of root-nodule bacteria in Australia.

The tube method of determining nodulation and effectiveness in nitrogen fixation:
General description, nature of the medium, determination of plant response, criterion of effectiveness, sources of variation.

The specific relationship between plant and bacterium:
Specific invasibility, host determination of relative success in nodulation, specificity in fixation; influence of host variety on symbiosis between *Medicago tribuloides* and *Rhizobium*.

The ability of "native" strains to fix nitrogen in association with pasture legumes:
Trifolium species, species in the *Medicago* group.

Serology of Rhizobium:
General, *R. trifolii*, *R. meliloti*, stability of serological properties, relationship to other properties, application of serological methods.

The distribution of strains of rhizobia:
Strains in a restricted area, multiple infection of the one plant, multiple infection in the one nodule.

The establishment of added inocula:
Methods of study, strain of organism, quality of inoculum, method of applying inoculum, conditions in the soil, competitive effect of native organisms, examples of success with seed inoculation, control of the quality of legume seed inoculants.

Variation:
Cultural characteristics, serology, symbiotic properties, bacteriophage sensitivity, correlated variation.

J. M. VINCENT.

(Awarded the Degree of D.Sc.Agr. by the University of Sydney in 1956.)

A COMPARATIVE STUDY OF WATER RELATIONS OF DROUGHT TOLERANT AND DROUGHT SUSCEPTIBLE VARIETIES OF SUGAR CANE

Three varieties of sugar cane, namely, Pindar, Queensland 47 and Canal Point 29/116, grown in different parts of Queensland, receiving various moisture supplies, were known by the experience of the farmers to be different in their drought tolerance. A comparative study of the water relations of these varieties was made by growing them at Brisbane, and conducting various tests on plants in both pots, and the field. The experiments were centred round two main characteris-

tics, namely, moisture economy and drought tolerance.

The transpiration ratio of these varieties was found not to be correlated with moisture economy or drought tolerance.

Of the various xeromorphic characters studied in these varieties, (i) the extent of internal and external transpiring surface, (ii) the role of stomata in regulation of transpiration and (iii) the root system were found to be important. Efficiency of the root system of these varieties in absorption of moisture was assessed from capacity for root elongation at high moisture tensions. The varieties, in descending order of moisture economy, were C.P. 29/116, Q.47 and Pindar. There were less fluctuations in relative flaccidity of Q.47 than of C.P. 29/116.

Evapo-transpirational losses of cane were found to be about 45 inches during the growing period of 11 months. No varietal differences were noticed in this respect, under the conditions of abundant moisture supply that prevailed during the growth.

It was observed that growth of sugarcane is depressed before the soil moisture reaches wilting point. A resistance of more than 25,000 ohms by gypsum blocks embedded at two suitable depths, preferably 12 inches and 24-30 inches in the soil, can be taken as an index for the need of moisture supply for young cane plants.

Rate of increase of resistance of the gypsum blocks embedded in the root zone of sugar cane remained uniform for all soil layers in which a certain minimum quantity of roots had permeated.

The field of drought tolerance was broadened and the problem was treated as a single complex characteristic of "hardiness", which was studied by exposing the three varieties to various unfavourable environmental treatments, such as frost, heat and submergence of roots. The varieties in descending order of hardiness were Q.47, C.P. 29/116 and Pindar, in all the tests.

Of the various characters observed, cell size was the only one associated with hardiness of the varieties. The role of osmotic pressure, pH and specific conductivity of leaf tissue fluids is considered doubtful.

Practical applications of the investigations and a line of further approach are discussed.

N. G. DASTANE.

(Awarded the Degree of Ph.D. by the University of Queensland in 1955.)

COMPARATIVE EFFECTS OF NITROGEN, PHOSPHORUS AND THE MICRONUTRIENTS ON RICE AND OATS ON A LATERITIC SOIL

Three sets of pot experiments with rice as the test plant under water-logged conditions were conducted using the impoverished Kangaroo Island soil. One dealt with its responses to the addition of phosphate and nitrogen and the other two to the micronutrients; manganese, molybdenum, copper and zinc applied singly and in combination. The effect of gypsum and lime on the uptake of these micronutrients was also studied.

Analysis was made for yield, nitrogen and phosphate in the N and P experiment. In the micronutrient experiments analysis was made for yield and the elements, Cu, Mo and Zn, at the flowering stage and at harvest for grain and straw separately. The results obtained were compared mainly with the work of A. G. Tyson, who had worked with oats and subterranean clover on the same soil.

Results:

The major portion of nitrogen applied as ammonia was not taken up. The amount utilized was conspicuously low when compared with oats. Naturally occurring nitrogen compounds in the soil

were more readily available to the rice plant.

The uptake of phosphorus was more efficient under water-logged conditions.

The elements Cu, Mn and Mo, were much more available to rice under water-logged conditions than they were to oats or subterranean clover under dryland conditions.

Gypsum at the rate of one ton per acre reduced the uptake of Mo by half. In combination with Zn, gypsum delayed the maturity of the rice plant.

Lime reduced the uptake of all the micronutrients examined, including Mo. The reduction of Mo uptake by lime was much less than by gypsum but was still significant.

Temporary Zn deficiency symptoms similar to those described by Barnette and Warner (1935) for maize were noted. It is probable that rice has a high Zn requirement.

Conclusion:

It might be more advantageous to add artificial nitrogen fertiliser to the dryland crop in rotation with rice. The residues from dryland crops and bulky organic manures would be good sources of nitrogen for rice. The rest of the elements are probably more available under water-logged condition and if the dryland crop is adequately fertilised, the subsequent rice crop may require little or no fertiliser.

K. KANAPATHY.

(*Awarded the Degree of M.Sc. by the University of Adelaide in* 1956.)

A POLAROGRAPHIC AND TURBIDIMETRIC INVESTIGATION OF THE CASEINS IN COW'S MILK

A polarographic investigation of the dye-binding properties of the caseins in milk as affected by heat and enzyme action suggests that the casein molecule exists in the "denatured" state.

Changes in pH, sodium, calcium and magnesium, and the action of heat affecting the particle size distribution of the casein micelles in milk are reflected in the light scattering properties of the sample.

By following changes in turbidity of milk on the addition of increasing amounts of calcium and magnesium complexing agents it is possible to estimate calcium and magnesium concerned in holding together the casein micelles.

A survey of several milks showed that each sample has individual turbidity characteristics. Factors influencing the stability of the casein system in milk are discussed, and it is suggested that turbidity measurements may lead to an estimate of the stability of a given sample.

Possible applications of light scattering measurements to the condensed milk industry are discussed.

N. S. SNOW.

(*Awarder the Degree of M.Sc.Agr. by the University of Sydney in* 1956.)

STUDIES ON THE NITROGEN CYCLE UNDER SYSTEMS OF CROP ROTATION

The influence of several four course rotations on the fertility and nitrogen status of Urrbrae loam in South Australia was studied and compared with a wheat-bare fallow rotation. No marked differences could be demonstrated in the total carbon or nitrogen in the soil as a result of the rotations, which had been operat-

ing since 1937. However, the surface soils in those rotations which included a legume as forage crop showed the highest values for readily available nitrogen, whether determined by incubation or by acid hydrolysis. These rotations were superior to the wheat-bare fallow rotation. In general, the nitrogen was more readily mineralizable in the grazed portions of the different rotations.

Fluctuations in mineral and mineralizable nitrogen throughout the season were followed in the fallow plots of three rotations. Except when all values were extremely low because of heavy leaching during the excessively wet period of midwinter, both mineral nitrogen and mineralizable nitrogen were higher in the rotations containing peas, particularly the grazed rotation, than in the wheat-bare fallow rotation. The mean nitrogen content of the wheat crop in the last full cycle of each rotation was found to be correlated with the available nitrogen in the soil in the autumn of 1955.

During the course of this work it was necessary to examine the optimal conditions for incubation in the laboratory and it was shown that any factor that led to loss of structure and aeration of the soil after sampling would lead to erratic results and affect nitrification adversely. Provided that structure was maintained, optimum nitrification was found to extend into a wider range of moisture contents than noted by previous workers. Consistently reproducible results could be obtained by drying soils at 45°C. before commencing incubation tests. This avoids the adverse effects resulting from the sampling of wet soils for subsequent incubation.

A. J. JEEVARATNAM.

(*Awarded the Degree of M.Ag.Sc. by the University of Adelaide in* 1956.)

LETTER TO THE EDITOR

Agricultural Science—Sydney University

Dear Sir,

It is unfortunate that Professor McClymont in his article on the Faculty of Rural Science at the University of New England* made statements with regard to the curriculum in Agricultural Science at Sydney University which are grossly misleading. The statements are—

> "However the successes of such graduates in solving many problems of animal health, soil fertility and pasture establishment, has resulted in a situation where some of the major factors limiting efficiency of livestock production are not those usually studied in depth in either course of training. These factors are the nutrition, breeding and management of the livestock, and appreciation and management of the soil-pasture-livestock complex as a biological and economic whole . . . And in agricultural science the emphasis is on the soil and the plant, in all their aspects, with largely only orientating reference to livestock."
>
> "However such extra emphasis on animal husbandry in courses of agricultural and veterinary science, though very overdue, does not meet the need for a course specifically orientated about the fields of knowledge involved in livestock production, with opportunity for specialization again within that field, such as, in sheep, beef cattle, dairy cattle or poultry science, or livestock nutrition or breeding. Specialization in animal husbandry in existing courses as is now planned in the Faculty of Agriculture at Sydney, or post-graduate training, although both playing valuable roles, cannot fully meet the need."

The curriculum in Agricultural Science at Sydney University has been developed over the past 47 years. During this period the School of Agriculture has provided the community with some 600 competently trained graduates who by their performance, have shown their value in many phases of Agricultural Science; for example, microbiologists, plant breeders, plant pathologists, soil scientists, chemists, agronomists, agrostologists, teachers, economists and animal husbandrymen. Many have reached the top of their profession and occupy such positions as Professors and Lecturers, Chiefs of Divisions of C.S.I.R.O., Under Secretaries and Directors of Agriculture, Principals of Agricultural Colleges, Chiefs of Divisions and heads of sections of Departments of Agriculture, Directors of Rural Education, teachers in high schools, leaders in some phases of agriculture in industry, and research workers, many with an international reputation in a wide range of agricultural sciences. Others have gone on the land and have become prominent farmers and graziers.

*J. Aust. Instit. Agric. Sci., Vol. 22, 252-254, 1956.

A	B	C
	First Year	
	Agricultural Economics I	(Same as group A)
Botany	Botany	" " " "
Chemistry	Chemistry	" " " "
	Economics I	
Elements of Agric.	Elements of Agric. (modified course)	" " " "
Physics		" " " "
Zoology	Zoology	" " " "
	Second Year	
Agricultural Botany	Agricultural Botany (modified course)	(Same as group A)
Agric. Chemistry I		" " " "
	Agricultural Economics II	
Agronomy I	Agronomy I	" " " "
Animal Husbandry I	Animal Husbandry I	" " " "
	Economics II	
	Economic Statistics	
Soil Science	Soil Science (modified course)	" " " "
	Third Year	
Agric. Chemistry II		Agric. Biochemistry
Agric. Economics I		Agric. Economics I
	Agric. Economics III	
Agric. Entomology		Agric. Entomology
Agric. Microbiology		Agric. Microbiology
Agronomy II	Agronomy II	Agronomy II (with exception of Horticulture)
Animal Husbandry IIA	Animal Husbandry IIA	Animal Husbandry IIA
		Animal Physiology
	Economics III	
Genetics		Genetics
	Government I	
Plant Pathology		
Statistical Methods		Statistical Methods
	Fourth Year	
(Candidates in the fourth year take one of the subjects listed in the appropriate group below but a candidate may take a composite course approved by the Head of the Department.)		
Agric. Chemistry		Agric. Chemistry
Agric. Economics	Agric. Economics	Agric. Economics
Agric. Entomology		Agric. Entomology
Agric. Genetics		Agric. Genetics
Agric. Microbiology		Agric. Microbiology
Agronomy		Agronomy
		Animal Husbandry
General Agriculture		General Agriculture
Plant Pathology		
Soil Science		Soil Science

Now with the establishment and development of a strong Department of Animal Husbandry, the training in this field will be even better.

The curriculum in Agricultural Science at Sydney University is given in the above table. Students may elect to take the A, B or C curriculum.

In the first three years this curriculum provides a broad general training in the Sciences which relate to soils, crop production, animal production and agricultural economics, with an adequate balance between them. The courses of study deal with the principles of the subjects and avoid a mass of unnecessary detail. At the end of the three years a student may take the degree of Bachelor of Agriculture or he may stay on for a fourth year to undertake specialised work and receive the degree of Bachelor of Science in Agriculture. The fourth year is designed to provide for specialisation either intensively in one field of Agricultural Science or more broadly over several fields.

The Fourth Year work in Animal Husbandry, in which Professor McClymont is especially interested, includes one term at the University and two terms at the new University Animal Husbandry Farms at Cobbitty, where intensive work in Animal Husbandry will be undertaken. For this programme, the staff of the Animal Husbandry Department will be assisted by leaders in various fields of Animal Physiology, Animal Nutrition and Animal Breeding from the C.S.I.R.O. laboratories at Prospect and the Animal Genetics Section at Sydney University. One of the strongest arguments in favour of this Sydney course is the fact that there is a large pool of such specialists available to give advanced courses to senior students—**a situation unique in Australia.**

For either the degree of Bachelor of Agricul-

ture or Bachelor of Science in Agriculture a student must obtain at least six months practical farm experience on approved progressive farms. His experience must be in at least four of the major agricultural industries.

It will be noted that, with the exception of the full course in Agricultural Economics, one of the main features of the curriculum in Agricultural Science at Sydney University is that it leaves a wide range of choice of subjects open to the student until late in the course. He does not have to make any choice until third year and then he is required to decide between Animal Physiology and Plant Pathology, a choice which should not be difficult. His main decision comes at the end of the third year after he has done at least one term's work in practically all phases of Agricultural Science.

Such a curriculum is of inestimable value to the student. It enables him to get the best of a University course and it also enables a University to get the best from a student, which must be considered a very great achievement in University education.

Yours, etc.,

J. R. A. McMILLAN.

Dean, Faculty of Agriculture.

School of Agriculture,
University of Sydney,
Sydney.

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TALKS

Recent Developments in Relation to Land Use in Northern Australia

Mr. C. S. Christian,
Land Research and Regional Survey, C.S.I.R.O.

An address to the South Australian Branch.

Mr. Christian dealt with that area of Australia which is strongly affected by the North-west monsoons. The rainfall pattern, 60 inches p.a. along the coastal extremities, grading to 10 inches at Alice Springs, and to 5 inches south of Alice Springs, is the dominating influence in the north. Before the war agriculture in this area consisted of a few vegetable and peanut farms, cattle grazing was the main industry and consisted of two seasonal hunts. During the war troops were supplied with vegetables from the Katherine area.

Since the war the Kimberley Research Station was established jointly by C.S.I.R.O. and the Western Australian Government. Scientific surveys in the Katherine-Darwin region, begun in 1946, have covered nearly half a million square miles. Later the Katherine Research Station was set up, and work is being done in association with the pastoral industry at Alice Springs. These surveys are conducted by teams of geologists, geomorphologists, botanists, pedologists, agriculturalists, etc., and the survey is aimed at describing the country and assessing its potential.

I. *Rice Growing Potential*

Rice growing has been attempted in four different projects, namely—

(a) Fitzroy River area, where the N.S.W. Rice Millers' Association has started a project, is flood plain country and annual flooding has been relied upon; the duration and irregularity of the water is proving unsuitable. However, a farm has been established on an ana-branch by Kim Durack. Some water control has been possible and the lateness of the season due to the flooding is favouring the temperate rice varieties from N.S.W. Yields of 30 cwt/ac are being obtained over the 80 acre farm.

(b) Kimberley Research Station, where they have controlled irrigation by pumping from the River. The main work has been variety selection, and suitable Japonica and Indica types are being selected for their appropriate season.

The northern rivers region of the Northern Territory also offers possibilities for rice growing, both on the downstream estuarine plains and on the upstream fresh water flood plains. In the downstream plains area the land surface is quite senile, with meandering river courses, a flat gradient of about one foot to the mile, and the soils are impermeable heavy clays. The rainfall is about 60 inches p.a. which in itself would be sufficient for rice growing if suitably distributed. For three or four months they are intermittently flooded. The upstream plains are better drained with a gradient of about 7 feet to the mile and flooding periods are therefore shorter. The soils are again suitable for rice, being light grey clays or bull-dust soils which powder on drying.

(c) The Humpty-Doo project has been started by an American syndicate, which has rights to the downstream plains east of the Stuart Highway. There are similar areas to the west of the Highway. Nowhere else in the world is rice grown in the way being attempted here, namely by extreme mechanisation over large areas with very little control of water. Rice *will* be grown in large quantities but there are many technical problems to be overcome. Wild geese, for instance, constitute a considerable menace, and C.S.I.R.O. has begun investigations of a basic nature. A possible control has already been suggested: the birds nest only in a restricted depth of water, between one to two feet deep, so that elimination of such conditions for certain periods by hydrological control might be possible. This control would also offer some solution to the problems of failures due to undue flooding or drought conditions.

(d) Bull-dust soils of the Upland Areas. The Northern Territory Administration has an experiment on these soils 60 miles east of the Stuart Highway. Rice grows better here than on the coast and one farmer has been assisted in developing a rice farm. Water is being controlled to some extent in small conservatories and yields of 25-40 cwt/acre are obtained. This is quite high compared to the 40 cwt/acre

yields of the M.I.A. in N.S.W. which is in a favoured temperate area. (c.f. India has yields of 800 cwt/acre.)

The main problem of rice growing in Northern Australia is the lack of water control, and investigation of the hydrology of the region is badly needed.

II. *Dry Land Agriculture*

The Katherine Research Station is in the 20-30 inch rainfall zone; the soils are light in texture and not highly fertile. Phosphate appears to be limiting. Sorghum and peanuts have been grown successfully, yields of 25 bushels/acre and 2,000 lbs/acre are not uncommon.

In the pastoral field some promising leads have been obtained. Normally 5-8 beasts per square mile are carried in the area, but with improved pastures it has been possible to increase this figure to 60 beasts per square mile for six months of the year. It has also been found possible to carry stock through the dry season on Buffel grass and Townsville lucerne.

III. *A Planning Scheme for Unknown Regions*

The present scheme for investigating the agricultural possibilities of Northern Australia consists in selecting the choicest areas and testing them by means of subsidised demonstration farms. The whole question of economics has to be worked out but it seems that agriculture can be practised, and might eventually take over much of the cattle grazing areas as has happened in other countries. Cattle grazing has been the common form of exploitation of similar regions throughout the world. Fortunately in Australia the shortage of water has up till now prevented excessive erosion and denudation of the country.

IV. *Conclusion*

There are two reasons for the investigations of the agricultural potential of Northern Australia; firstly, to uncover the very worthwhile economic potential that exists there, and secondly, from the international aspect, a plan for development is necessary. The suggested settlement of several million Asiatics in the North would only be unfortunate in adding still another over-populated under-privileged area to the world, whereas, its development as a large scale food producing scheme along the rice project lines would be a distinct advance.

Range Pasture Management in Arid Regions of the U.S.A.

Dr. R. L. Specht, University of Adelaide
An Address to the South Australian Branch

Dr. Specht gave a comprehensive survey of the ecology and problems of range management in the semi-arid regions of the United States. This area includes some 200 million acres of land bordered on the east by the Rocky mountains, on the west by the Sierra Nevadas, and extends from the Mexican border in the south for almost fifteen hundred miles northwards to Idaho and Washington. The desert area divides naturally into two distinct types, a cold desert in the North and a warm desert in the South.

The northern part of the cold desert has a comparatively reliable winter precipitation of snow and rain averaging 5" to 10" and average winter temperatures of 20° and 25°F. This area is used only for spring and autumn grazing of Rambouillet and Corriedale sheep, and carries only about one sheep to 20 acres. The natural pastures are a mixture of *Agropyron* grasses, browse (*Balsamrhiza* sp.) and sagebrush. The chief problem in efficiently grazing the area is to achieve maximum utilization of the pasture without allowing the inedible sagebrushes to become dominant. This has been achieved by moderate grazing (14 sheep-days per year) restricted to the spring and autumn months. In places where over-grazing has enabled the sagebrushes to become dominant, regeneration of the grasses has been achieved by restricting grazing to the autumn months alone.

In the winter months the sheep are moved southwards to the warmer parts of the cold desert and are grazed on the natural pastures of *Atriplex* spp., *Kochia* sp., and *Eurotia* sp. or where possible on irrigated pastures.

The warm desert in the Southern states has comparatively warm (40°F) winter temperatures and a most unreliable summer rainfall of from 5" to 20". Droughts as long as five years are not unknown in some parts where the only permanent vegetation is cactus and creosate bush (*Larrea divaricata*). The Eastern desert savannah areas of Texas, New Mexico and Eastern Arizona are used for rough cattle grazing, and in the rare good years are most highly productive. In recent years the mesquite tree (*Prosopis* spp.) has been spread widely by the grazing cattle, and is limiting pasture growth to such an extent that its destruction by aerial spraying with 2,4,5,T has proved an economic venture. Recently it was shown that in drought times the timber of this tree (which somewhat resembles mulga) can be used as a valuable stock feed after it is finely ground. In this area stock are grazed during the summer months on black grama grass (*Bouteloua eripoda*) and tobosa grass (*Hilaria mutica*), but in the winter months they must be restricted to the grama grass as

the tobosa is unpalatable. An interesting successful method of sowing side oats grama grass in six foot water catchment troughs which are ploughed throughout the area has recently been developed. In an area having such an unreliable rainfall as this warm desert, the problems of maintaining agricultural production at an economic level are immense.

The Use of Radio Active Isotopes in Agriculture and Industry

Dr. J. N. Gregory, Chief, Radio Isotopes Division, Atomic Energy Commission, in an address to the N.S.W. Branch.

Dr. Gregory commenced by defining certain terms and discussing properties of isotopes, their detection and measurement. Dr. Gregory then began to illustrate, by using numerous examples, the three main ways in which isotope radiation may be used in either research or, by direct application, in industry. The three main ways are:—

1. *The "Tracer" Principle.* Isotopes or "labelled" elements may be traced through a reaction or process. The uptake of phosphorus from the soil and its distribution through the plant may be studied by this means, the principle advantage of which is that it is possible to distinguish between the experimentally applied phosphorus and that occurring adventitiously. Studies of foliar absorption of nutrients (particularly of urea using labelled carbon), are greatly facilitated by using isotopes. Most commonly used isotopes in plant nutrition work are calcium, sulphur, zinc, cobalt, carbon, potassium.

In particular, the use of the isotope of carbon (C^{14}) has enabled workers to study photosynthesis and the carbon cycle, determining the intermediate stages.

Extremely accurate quantitative measurement of certain trace elements is possible using isotopes.

Estimation of insect populations is possible by liberating a known number of "labelled" insects and sampling the population later to determine the proportion of "treated" insects. Tracing the path of liberated insects underground, in wood, etc., is a further use.

Most weed-killers, hormones, insecticides, fungicides, etc., are available in isotope labelled form, thus allowing for closer study of their action.

Isotopes assisted considerably in studying irrigation in sugar cane in Hawaii. The amount of water penetrating the soil was measured by the isotope content at the surface.

2. *Effect of Materials on Isotopes and Radiation*—by placing a material between the source of radiation and a detector, the amount of attenuation recorded is quantitatively related to the mass or thickness of the intercepting material. Thus it is possible to measure moisture content of clays; density of soil, hollowness of trees; height, density, etc., of crops. In industry this principle is used in measuring mass transfer on conveyor belts, etc. In measuring crop growth it is possible to not only continuously record increase in height but measure increase in mass growth which is more significant.

3. *Effects of the Isotope and Radiation on Materials*—mainly concerned with sterilising and preserving of food products. Simplest examples are the elimination of insects from flour, wheat, dried fruits by subjecting the material to radiation. The process is cheap and post-package sterilisation is possible. Treatment of dairy products unfortunately results in "off" flavours but there are possibilities of successful treatment of meats, especially pre-cut meats.

Eradication of the screw-worm insect from an island was achieved by irradiation of male insects, this resulting in infertile eggs, reduced insect population and eventually eradication.

In reply to questions, Dr. Gregory pointed out that irradiated materials are not contaminated by the process; that isotopes of nitrogen are too short-lived to be of use for research, and that some of the other short-lived isotopes will be available from the Lucas Heights plant towards the end of 1958.

Ecology in the Development of Land Resources

Mr. R. G. Downes, Deputy Chief, Soil Conservation Authority of Victoria, in an address to the South Australian Branch.

Overspecialisation by scientists is harmful to agriculture. In some fields it has become so great that we are not sufficiently aware of where our work fits the broad pattern.

In medicine this approach has shown with antibiotics. The drugs were used without understanding the delicate ecological balance being tampered with. They have certainly been spectacularly successful, but now many scientists have misgivings.

In agriculture, we face the same type of problem. We are tampering with the natural climax eco-system, which is stable. Any attempt by man to change this environment is beset with dangers—the wrong action may lead to ruin.

Like other elements in the eco-system, man must enter into harmonious adjustment with his environment or suffer the same fate of other species which fail to adjust themselves. Accordingly, there must be an appreciation of the inter-relationships between plants, animals, soils, climates, hydrology, physiology.

Like the antibiotics, spectacular scientific discoveries such as trace elements might make temporary advances, but over-all progress depends on finding where these fit the broad picture.

There are many practical examples.

In Victoria, for instance, the recent upsurge of pasture improvement by aeroplane in mountain country raises doubts.

There, farmers are using pelletted seed to establish clovers on steep country. This is an immediate step forward, for the clover will increase production.

After some years however, weeds might invade the nitrogen enriched hillsides, replacing the natural grasses.

These weeds are quite good stock feed, but in a dry year they are likely to pack up, leaving the soil with little protection. The erosion risk would be extreme.

If this happened, the final balance might leave us worse off than if the land had remained under natural grasses. Production might have been lower, but these grasses would have held the slopes better in drought.

A better understanding of the basic ecology is needed for there is a danger of such technological advances being incorporated into the system without due thought to significance and effect. After all, the solution to one set of problems creates others and the experimental results today need not be the answer 40 years from now. The dynamic nature of land-use research should be reckoned with.

Land Development

In land development, we intentionally destroy the existing equilibrium of the eco-system, to introduce more suitable plant and animal species. By doing this, with the help of fertilisers and sound management, we seek a higher level of sustained productivity. We hope to evolve a new eco-system in equilibrium.

However, there are two major difficulties due to man himself being part of the eco-system.

- Man wants to harvest and transport, which is a drain on the eco-system.
- Man's behaviour is not necessarily biological. Instead, he reacts to economic, cultural and emotional factors. These can be variable and unpredictable.

In spite of these difficulties, we must attempt to apply ecological principles to land use. Otherwise we will use up our environments rather than live with them.

We could make better use of the ecological approach in planning land development on a regional, local or farm scale.

Perhaps on the broadest pattern, we are too late. The pioneers did this largely by trial and error. Fortunately, they made surprisingly few mistakes.

On the regional scale, the approach can still help us. For instance, in the Victorian Mallee the general run of the dunes is from east to west. But the land has been laid out in squarish blocks. Perhaps farmers could have subdivided more satisfactorily and more economically had the land been moulded to fit the direction of the country.

Despite the advance of technology and chemistry, we still rely on our land resources for our food and our prosperity. This is unlikely to change for many years to come. Therefore, we must plan to use the available resources to the best advantages.

More awareness of the overall ecological pattern will help us do this better.

Land use around our major cities needs better planning, too. The "urban explosion"—as they call it in America—is swallowing much valuable agricultural land, such as the market gardens and orchards lost in Melbourne's expansion.

Cities must inevitably expand, but great care should be exercised in the selection of farm land for industrial and suburban use. Land having the greatest range of potential uses should be maintained for "flexible" forms of land use.

Chemistry for Agriculture

Professor R. K. Morton, Professor of Agricultural Chemistry, Waite Institute in an address to the South Australian Branch.

Agriculture rests squarely on the science of Chemistry. In 1840 Liebig, who is called the Father of Chemistry, from analyses of plant and animals realised the importance of minerals, e.g., N, P and K, and so the interaction between the soil and the plant. The great German school of chemistry developed and carried on his work up to the time of Warburg.

Sir Frederick Garland Hopkins made the next major contribution by associating physiology closely with chemistry. He changed from the pure Liebig analysis to the dynamic study. He said that biochemistry arose from the union of physiology and chemistry.

Professor Morton felt that only by a study of living cells and by exercising an increasing control on the living processes, could agriculture be treated as a science rather than as an art or a craft. The success of the application of chemistry to agriculture will depend on how well the chemist is guided by the practitioners of agriculture. In medicine the general practitioner refers his problem to various specialists, e.g., eye, brain or bone specialists—this has been the big advance in medicine in recent years—the same cannot be said for agriculture although lately some attempt has been made on this approach. The fault appears to lie with the agriculturist in not defining his problem correctly and often in not referring it to the specialist. What are the present day problems of Agriculture? They can be expected to fall under four main headings:—

1. The economic improvement of soils with fertilisers, etc., with a view to increasing yields.
2. Economic treatments to improve the quality of products.
3. Economic protection of crops and stock from diseases and also crops from weeds.
4. Preservation and transport of produce.

All of these processes may be referred back to the quantitative and qualitative aspects of the synthesising processes occurring in living cells, processes synthesising proteins for food or as wool for clothing, or fats and other carbohydrates. There are three good examples of recent advances in biochemistry which illustrate very well the process and interrelations occurring in living cells and which give a lead on how knowledge and control of these processes might be used agriculturally. They demonstrate how new fields of thought may be opened up by building up of fundamental knowledge of processes.

1. Plant-Soil Relationships—The uptake of nutrients by plant roots against a concentration gradient has posed the problem of explaining the chemical mechanism by which the plant is able to supply the energy required for the reaction. Dr. R. N. Robertson of Sydney and also Lundegardt have been able to demonstrate the process called oxidative phosphorylation. An interesting feature of the process is that the generation of the energy-carrying compounds requires the presence of the ion to be absorbed. Furthermore the enzymes responsible have been located in the mitochondrial bodies (slides of cells were shown at up to 40,000 magnification) and the lipo-protein membranes which are concerned with the processes were demonstrated. How, for example could the mechanism for ion transfer be upset so that low soil solution concentrations of phosphate ions be sufficient for plant growth.

II. The formation of storage forms as proteins, fats, starch, etc., also offers another area of knowledge which might be practically applicable. Control of the activating and inactivating enzymes which catalyse these processes could allow us to dictate when and to what extent the products of photosynthesis might be deposited.

III. The growth processes of living cells and the differentiation of young tissues.

These processes are again concerned with enzymes. It has been shown that enzymes concerned with the same chemical processes in different body tissues (e.g., the phosphatases in the mammary gland and in the intestines of the cow) are not identical, whereas enzymes from the same type of tissue and concerned with the same process in different animals are the same. These proteins must differentiate at some early stage in the embryonic tissue and in this way must the development of the different types of tissues be determined.

Recent developments in technique give a lead on how this field might eventually be understood. Stanford Moore's work on separating the amino acids chromatographically combined in Simmond's method of protein analyses now make it possible to distinguish protein types and so eventually open the way to modifying protein development and influencing the quality of agricultural produce.

Professor Morton concluded by saying that dynamic steps must be taken to remove the natural hazards from farming and to replace them with true scientific control.

Land Use Surveys

Mr. G. H. Lawton in an address to the South Australian Branch

Very early descriptions of land use and land resources were given by the Greeks, Chinese, Scots, etc. These were always incidental to other factors being studied.

It was not until this century that specific surveys of land resources were commenced. Work, started in 1908 as part of the U.S. Geological Survey, was the beginning of modern Land Use Classification. In 1925, Prof. Sower of Michigan suggested that basic geographical studies should include a Land Use Map in addition to maps of topography and soils.

Land use studies have helped in the formation of Government policies, as in the sub-marginal cut-over regions of Michigan and Wisconsin where the re-location of farmers on better land was found to be the only solution.

Specialists such as conservationists, economists and social scientists have entered the field and developed land use planning techniques specific for their own problems. The Tennessee Valley Scheme is a good example of land use planning.

The land use concept is tied closely to agriculture because of its basic importance. However planning must be specific in terms of actual use, and other factors such as urban development, mining, etc., must be taken into account. Primary surveys give information on the basic physical characteristics of a region. These must be followed up with studies to determine the reasons for existing land use patterns. Land use is determined not only by the physical aspects of a region but also very largely by human factors. Agriculture in South Australia is, in part, lying dormant because of the over-riding effects of social and economic factors.

In the Co. Hindmarsh survey carried out by the University of Adelaide Geography Department the basic unit of area for study was the land section. Individual sections were marked on aerial photographs from Department of Lands surveys. These photographs were then used in the field for recording basic information about each section. This data was later transferred to a Master Map of the area.

By combining information from a Slope & Drainage Map, a Soil Map and a Length of Growing Season Map, it was possible to delineate 16 different "land type" areas within the County (e.g., type 16, podsols with 7-8 months growing season).

A random sample of landholders within each of these land type areas was studied by means of interview and questionnaire. Information, which was not available from the primary survey, on the reasons for the types and levels of agricultural production was thus obtained.

A land use survey of this type is the first step towards the solution of problems like faulty agriculture, and undeveloped land. In addition, single topic maps prepared from the master map (e.g., dairying, land tenure, state of development, etc.) can be used for the planning of such things as electricity supply, dairy factory placement, roads, etc.

The Nutritive Value of Some Sub-tropical Pasture Species

An address delivered to the Queensland Branch by R. Milford, C.S.I.R.O., Cooper Laboratory, Lawes, on 28th August, 1957.

The objective of increased animal production in sub-tropical and tropical Australia, which will most certainly be realised from better pasture utilization, can be greatly accelerated if the agrostologist has at his command knowledge relating to the nutritive values of his pastures.

The information available on feeding values of tropical and sub-tropical pasture plants is extremely small; on the other hand much is known about the chemical composition of these species. The practice of interpreting chemical constituents in terms of nutritive values is widespread, but unfortunately it has been shown that chemical analyses *per se* can sometimes be most inaccurate criteria. However, the usefulness of chemical data would be greatly enhanced if more precise expressions of the nutritive value of a feeding stuff in terms of its chemical composition could be found. Very little has yet been done towards establishing such relationships although recently East African workers showed that the crude protein content of a feed was significantly related to crude protein digestibility.

Work at Lawes is aimed at providing data on nutritional values of sub-tropical pastures as a whole and on the individual species which go to make up these pastures. Up to the present most information has been obtained from sheep fed and housed singly in metabolism cages.

It is recognized that data obtained from pens may not be directly applicable to field conditions mainly because selective grazing has been eliminated. It has therefore been necessary to consider, concurrently with these pen studies, a number of techniques that may be employed in measuring intake and digestibility of herbage consumed by the free grazing animal.

The fact that a pasture species does not possess a constant nutritional value is well recognized. There are differences due to stage of growth and also due to the reaction of that species to environmental factors such as drought, frost and rain. Quite clearly, therefore, precise assessments cannot be made unless data for the species under consideration are available at a number of stages of maturity and measurements are also made to estimate any changes attributable to external factors.

One of the earliest problems arising from the work at Lawes was the selection of suitable criteria whereby the nutritive values of the

various species could be compared. It was soon found that the expression of these values in terms of commonly accepted feeding standards, viz. starch equivalents (S.E.) or total digestible nutrients (T.D.N.) was most unsatisfactory.

The results of feeding trials at Lawes show quite clearly that the maintenance requirements estimated by means of standard feeding tables are greatly in excess of observed requirements. There is a need for basic information on both the nett energy requirements of various classes of livestock under sub-tropical conditions and nett energy values of the sub-tropical pasture species.

Even though much fundamental work is required it has still been possible to establish criteria by which the relative feeding values of our sub-tropical pasture species can be compared. Results to date from pen feeding experiments show that marked differences between species and also within species can be found in amounts consumed—all comparisons being made in terms of dry matter intake. Dry matter digestibility data are also valuable criteria but these are best interpreted in conjunction with dry matter intakes. The ability of a feed to satisfy protein requirements can be best expressed in terms of nitrogen balance, when such information is available.

When these criteria are applied to results obtained with sub-tropical grasses it is found that for a period of upwards of 6 months a year, during late autumn, winter and early spring, most grasses are unable to satisfy requirements for protein. It has been found with many species that this protein shortage is associated with a fall off in intake to very low levels. The low intake, coupled with falling digestibility, is clear evidence that such rations are unable to meet the animal's energy requirements.

From these findings it can be assumed that the seasonal losses in animal production in Queensland are attributable not only to a shortage of protein but also to a shortage of energy. Selection of new pasture species must be made with an eye to alleviating both these shortages.

The need for relating chemical analyses to more specific expressions of nutritional values has already been stressed. A number of relationships between various chemical constituents of some sub-tropical grasses and their dry matter intake, dry matter digestibility, crude protein digestibility and information on nitrogen balance has been obtained from our data. It is proposed to briefly deal with some of these aspects, discussing their significance.

There is a highly significant straight line relationship between crude protein content of sub-tropical grasses and dry matter intake. However, this relationship cannot be represented by one general formula embracing all species as the slopes for the individual species are different. This relationship should not also be regarded as one of cause and effect, except at very low levels of crude protein in the feed when the efficiency of the rumen flora is reduced due to inadequate supplies of nitrogen.

Another feed characteristic which is related to intake is succulence. This is demonstrated by a significant relationship between moisture content of the various forages and intake.

Relationships of dry matter digestibility to crude protein content and also to the moisture content of some sub-tropical grasses have been demonstrated. With some species, however, crude protein content is not related to digestibility.

The fact that moisture content is related to both intake and digestibility emphasizes the importance of species which are able to maintain succulence, particularly during the winter and early spring. Species which are able to resist frost or which are physically protected by their own bulk from severe frost damage should greatly increase the nutritional values of pastures during these times.

Calculations from our data show that the relationship between crude protein content and crude protein digestibility can be expressed by a regression equation of the form $y = b \log x - c$ where y = crude protein digestibility, x = crude protein content of forage and b and c are constants. The values obtained for these constants were 104.5 and 45.5 respectively. East African workers have also developed a similar regression equation but their constants differ significantly from ours. This difference becomes most apparent at crude protein levels below 5-6% when crude protein digestibilities calculated by our formula are considerably lower.

It has been mentioned that nitrogen balance data gives the most satisfactory measure of a forage's ability to satisfy protein requirements. Unfortunately, because of technical difficulties involved under field conditions, such data are generally only available when animals are pen fed. Relationships between nitrogen balance and easily obtainable field data could therefore be extremely useful. Best relationships obtained so far have been between nitrogen balance and crude protein content of forage and also nitrogen

balance and the total amount of nitrogen ingested/day. It is of interest that irrespective of species most of our sheep attain nitrogen balance at an intake of between 4-6 g. digestible nitrogen/head/day.

In conclusion it should be pointed out that our real problems lie in providing an adequate ration during the "off season". For this reason work at Lawes has been concentrated on studying species when they are lowest in nutritive value. It would appear that far better animal performance will be obtained if species are selected with an eye to intake, digestibility, protein content, and succulence as well as the other desirable attributes sought after by agrostologists.

Grazing in the Snowy Mountains

Professor J. S. Turner, Botany School, University of Melbourne, in an address to the A.C.T. Branch.

Professor Turner said that in all the high mountain catchments of New South Wales and Victoria there is marked deterioration of the natural vegetation cover and associated loss of catchment efficiency. There is widespread sheet erosion by wind and water in many parts of the catchments and big areas have been very severely damaged. Although at present there is little evidence of soil erosion of the rill or gully type and siltation is not excessive in the dams, nevertheless the deterioration of Mt. Bogong, Mt. Hotham and on the Main Divide near Kosciusko makes it clear that there is a serious risk of accelerated soil erosion which in time may reach catastrophic proportions. Such erosion could cut short the useful life of the complex system of dams, power stations and diversion tunnels in these mountains.

The deterioration of the vegetation is largely due to a combination of grazing and burning. The damage to the peat bogs is largely due to trampling, coupled in some cases with severe burning. It is believed that the deterioration was initiated during periods of intensive grazing especially during drought years and that the present grazing practice is causing further deterioration and erosion. Detailed measurements on areas protected from grazing show that the recovery of damaged areas is very slow. Locally the erosion is increased by insect attack, by the improper siting of access tracks to ski huts, and of course by the engineering operations of hydro-electric authorities. These authorities are, however, aware of the danger and through their soil conservation sections have been meeting it, except possibly at levels above 6,000 feet. Professor Turner said that after detailed studies of his own on Mt. Bogong and those of other colleagues, particularly Mr. Costin, in this area, it was suggested that the major procedure necessary to arrest any further decline in catchment values and to improve the position in the future is to place all catchments under the control of one competent conservation authority in each State and provide these authorities with sufficient powers and finance.

It would be a worthwhile aim if as soon as possible we could get complete exclusion of all grazing animals from these important catchments at heights above 4,500 feet. The exclusion of grazing should be carried out with due consideration shown to the graziers who have for so long been allowed to utilize the area and who may justly be compensated in the form of practical and financial assistance in improving their lowland pasturages.

Professor Turner did not envisage that the prohibition of summer grazing on the catchments would deprive the country of the wool and meat that is at present grown there under the system of snow leases. Some graziers advocate the spending of very considerable sums of money on pasture improvement in the mountains. Professor Turner suggested that if some of this were spent on the improvement of the lowland pastures and on facilities for storing fodder reserves, there need be very little if any reduction in the numbers of sheep and cattle grazed following their exclusion from the snow leases.

The multiplicity of questions following the address indicated the great interest that had been aroused.

Plant Nematodes

R. C. Colbran, Department of Agriculture and Stock, Queensland, in an address to the Queensland Branch

During recent years agricultural scientists have come to realise that phytonematology implies much more than the study of the root-knot nematode.

Plant nematodes can be classified into two main groups, viz.:

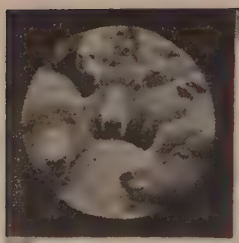
(1) Those attacking stems, leaves, buds and floral parts;

(2) Those attacking roots.

The former includes *Ditylenchus dipsaci*, the stem eelworm; *D. destructor*, the potato tuber rot eelworm; gall-forming species of *Anguina* including *A. tritici* (wheat eelworm); and various Aphelenchs—*Aphelenchoides ritzemabosi* (leaf scorch of chrysanthemums), *A. fraga-*

riae (red-plant and cauliflower disease of strawberries), *A. olesistis* (leaf blotch of ferns) and *A. cocophilus* (red-ring of the coconut palm). Of these *A. tritici, A. australis, A. ritzema-bosi, A. olesistis* and *D. dipsaci* have been reported in Australia.

Root attacking nematodes may be ectoparasitic, endoparasitic, sedentary or migratory in their habits. Important members of this group include the root-knot nematodes (*Meloidogyne* spp.), the cyst-forming Heteroderas, root-lesion nematodes (*Pratylenchus* spp.), the citrus nematode (*Tylenchulus semi-penetrans*), the burrowing nematode (*Radopholus similis*), dagger nematodes (*Xiphinema* spp.), sting nematodes (*Belonolaimus* spp.), stunt nematodes (*Tylenchorhynchus* spp.), ring nematodes (*Criconemoides* spp.), pin nematodes (*Paratylenchus* spp.), spiral nematodes (*Rotylenchus* spp. and *Helicotylenchus* spp.), stubby-root nematodes (*Trichodorus* spp.) and awl nematodes (*Dolichodorus* spp.). All of these groups have been found in Australia and their importance is now being studied.



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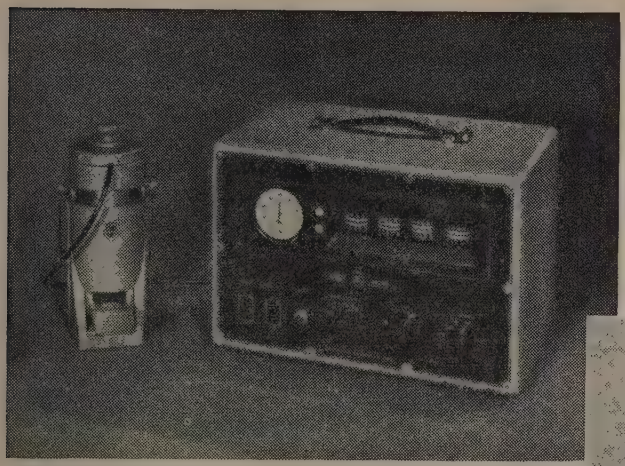

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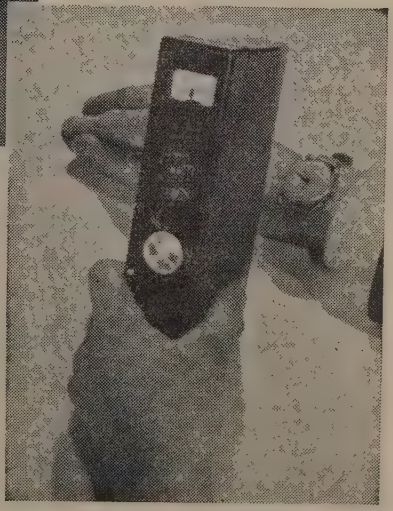

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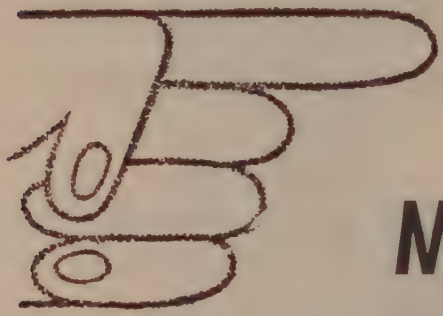

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NEWS ITEMS

New Course in Agricultural Economics Commencing in 1958

The Faculty of Agricultural Economics, recently established at the University of New England, is to commence tuition at the beginning of the 1958 academic year. The Faculty will provide a four-year course of training leading to the degree of Bachelor of Agricultural Economics. Facilities for postgraduate study and research are also available.

The undergraduate course will provide training in economic principles and their application to farm production, marketing and agricultural policy. A basic training in general economics and in the applied agricultural sciences, including agronomy and livestock husbandry, will be supplemented by specialised courses of instruction in farm management and agricultural economics. Other courses to be offered include statistics, economic history, rural sociology, mathematics, history of economic thought and public administration.

A somewhat flexible curriculum permits students in their senior years to undertake a substantial degree of specialisation in those fields of study most suited to their particular interests and career requirements.

Additional short courses are to be provided in such fields as agricultural extension methods, land valuation and research techniques. It is hoped to develop, as a feature of the course, a system of visiting consultants in which practising specialists from research agencies, advisory services, administrative and financial institutions, etc., will participate in the policy seminar and present short sequences of lectures in various parts of the course. The seminar on agricultural and economic policy will provide an opportunity for senior students to bring their training to bear upon current issues of industry and public policy.

Students will be required to take part in field excursions and practical work in both the agricultural science subjects and in farm management analysis, farm planning and the like. Students without a farm background will be encouraged to spend a vacation period acquiring experience on a farm or grazing property.

The course has been designed to equip students for a professional career as agricultural economists or farm management specialists. However provision has also been made for students whose primary interest is in general economic theory and for those who are not intending to take up a professional career in farm economics but wish to receive a fairly broad education in the social and natural sciences and in liberal arts subjects.

The Faculty is under the control of Professor J. N. Lewis, formerly Assistant Director of the Commonwealth Bureau of Agricultural Economics and Assistant Secretary of the Department of Trade. Dr. W. V. Candler, Ph.D. (Iowa), M.Ag.Sc. (N.Z.) has been appointed as Lecturer in Farm Management.

Students wishing to enrol in the Faculty and other persons interested may obtain full information about the course from the Registrar, University of New England, Armidale, N.S.W.

University Professor Awarded Doctorate of Agricultural Science for Important Cattle Research

Dr. N. T. M. Yates, Associate Professor of Livestock Husbandry at the University of New England, has been awarded the Doctor of Agricultural Science degree by the University of Queensland for a thesis entitled "The Photoperiodic Control of Coat Changes in Cattle with Particular Reference to the Tropical Adaptation of the European Breeds" together with supporting scientific publications.

Professor Yeates' thesis dealt with work carried out over a number of years while he was a Senior Research Officer in the C.S.I.R.O. Division of Animal Health and Production, located in the Physiology Department at the University of Queensland.

This research showed for the first time that the seasonal coat changes of cattle are regulated by changes in the duration of daylight. Having established this fact experimentally, Professor Yeates then examined the position of European breeds of cattle exposed to an equatorial light environment in which there is virtually no seasonal change.

He was able to show experimentally that under such conditions the normal seasonal coat changes of the cattle are eliminated and the animals tend to maintain permanently a woolly, heat-retaining type of coat. This is prejudicial to their heat tolerance and is one of the important reasons for the failure of European cattle to thrive in the tropics.

As a result of his extensive studies, Professor Yeates concluded that the best hope for the successful adaptation of European cattle breeds in the tropics lies in the selection of smooth coated individuals with the objective of producing pure breeding strains having this characteristic.

Australian Society of Animal Production Conference

The second Biennial Conference of the Australian Society of Animal Production is to be held at Melbourne University from 24th to 28th February, 1958.

The following provisional programme has been drawn up.

Monday, 24/2/58—
Afternoon: Meeting of Federal Council in person. Registration of Conference members.
Evening: Reception.

Tuesday, 25/2/58—
Presentation of papers and discussions. Official opening of the Conference by a Government representative. Presidential address.
Evening: General Meeting.

Wednesday, 26/2/58—
Excursion to Werribee—Animal Husbandry Research Centre (Vic. Dept. of Agr.). Poultry Research Centre (C.S.I.R.O.). Sewerage Farm (Melbourne and Metropolitan Board of Works).
Evening: Address by a prominent Guest Speaker.

Thursday, 27/2/58—
Presentation of papers and discussions.

Friday, 28/2/58—
Presentation of papers and short communications, followed by discussions.
Afternoon: Visit to industrial research laboratories.

Papers will be presented by research workers from C.S.I.R.O., Universities and State Departments of Agriculture and will be grouped under four general headings—

A. Animal Breeding,
B. Animal Nutrition and Pasture Management.
C. Animal Physiology.
D. Short Communications.

Information concerning the Conference is obtainable from the Society's Honorary Secretary, Mr. F. Skaller, c/o C.S.I.R.O. Poultry Research Centre, Werribee, Victoria.

Refresher School, Victoria — 2nd-5th September, 1957

The Refresher School was held at the School of Horticulture, Burnley Gardens, 2nd-5th September, 1957.

During the four days, lecturers reviewed recent developments in the basic sciences of agriculture relating to plant growth, enabling those who attended to obtain an up-to-date picture of present knowledge in the whole field of plant development and growth.

There were four lectures on each of the first three days, and three on the last day. Each lecture was for 45 minutes, with 30 minutes for discussion.

On the first evening, a buffet dinner was held to enable the Secretary to the Cabinet to open School on behalf of the Premier. This was attended by 83 members, 17 heads of industries, who had contributed to the Institute, and five heads of Government Departments.

A total of 145 applications were received for attendance at the School. These were made up of 128 applications from members, and 16 from non-members. As indicated by application forms, approximately half the total number of members attended the School full-time, as did also 11 of the non-members.

The average attendance per session was 89.

Programme

The sub-committee which organised the Refresher School felt that rather than attempt to cover every phase of Agriculture, the school should deal with a group of related subjects. Accordingly the general theme "The Growth of Plants" was adopted and a series of papers was presented dealing with recent developments in the basic sciences related to plant growth.

In retrospect it is fairly clear that this approach was a successful one, because it led to an integrated programme which gave a broad picture of the present state of knowledge in these sciences.

The programme was as follows—

Monday, 2nd September

"Structural and Functional Aspects of Intracellular Particles"—*Dr. F. J. R. Hird*, Senior Lecturer in Agricultural Biochemistry, University of Melbourne.

"Transpiration"—*Prof. J. S. Turner*, Professor of Botany, University of Melbourne.

"Photoperiodism"—*Dr. D. J. Carr*, Senior Lecturer in Botany, University of Melbourne.

"The Rhizosphere Concept"—*Dr. A. D. Rovira*, Research Officer, Division of Soils, C.S.I.R.O., Adelaide.

Tuesday, 3rd September

"The Leguminous Plant and its Associated Root-nodule Bacteria. Some Problems for which we have no Answer"—*Mr. J. R. Harris,* Research Officer, Division of Soils, C.S.I.R.O., Adelaide.

"Growth Habit as a Basis for Breeding New Varieties"—*Miss Y. Aitken,* Senior Lecturer in Agriculture, University of Melbourne.

"Raw Materials for Plant Breeding"—*Dr. O. H. Frankel,* Chief, Division of Plant Industry, C.S.I.R.O., Canberra.

"Induced Mutation as a Tool in Plant Breeding"—*Dr. R. D. Brock,* Senior Research Officer, Division of Plant Industry, C.S.I.R.O., Canberra.

Wednesday, 4th September

"The Importance of Virus Infections in Vegetatively Propagated Species and the Production of Healthy Stocks"—*Mr. L. L. Stubbs,* Senior Plant Pathologist, Department of Agriculture, Victoria.

"Some Aspects of Ecology Affecting Locust Control"—*Mr. T. W. Hogan,* Senior Entomologist, Department of Agriculture, Victoria.

"Plant Physiology and Crop Yield"—*Dr. T. F. Neales,* Lecturer in Botany, University of Melbourne.

"Phosphorus in Soils"—*Assoc. Prof. G. W. Leeper,* Associate Professor of Agricultural Chemistry, University of Melbourne.

Thursday, 5th September

"Antagonisms and Acidity as Effects in the Choice of Fertilisers"—*Assoc. Prof. G. W. Leeper.*

"How Far can the Deficiency Symptoms of an Element be Related to the Function of that Element in Plant Growth?"—*Dr. T. F. Neales.*

"Pasture Management in Relation to Utilisation"—*Mr. W. M. Willoughby,* Senior Research Officer, Division of Plant Industry, C.S.I.R.O., Canberra.

Lecture Notes

Each speaker has prepared a fairly complete summary of the paper given and these have been distributed in roneoed form to all those who attended the school.

"Cobalt Bullets"—A New C.S.I.R.O. Development

Millions of sheep throughout Australia are likely to be carrying "cobalt bullets" this season to correct cobalt deficiency which occurs in various areas throughout Australia and causes "coast disease" and unthriftiness. Cobalt supplements are normally given to correct these conditions.

Cobalt supplements are also important in the treatment of "phalaris staggers", a nervous malady which can affect sheep and cattle confined to pastures dominated by *Phalaris tuberosa.* It is frequently fatal and in some seasons and in certain areas it can lead to the loss of practically all stock grazed exclusively on the new growth of this plant.

Frequent drenching with cobalt solutions is effective in combating "phalaris staggers" but is impracticable with large flocks. Top-dressing of pastures with cobalt fertilizers is too expensive for large properties and in any case, its effects may be short lived. Salt licks are unreliable.

The animal does not store cobalt and needs small quantities at frequent intervals. The heavy "cobalt bullets" developed by C.S.I.R.O. offer an effective answer to the problem. They are relatively inexpensive and are easy to administer. One dosing should protect for many months, probably for some years.

The heavy "bullets" lodge in the rumen or in the adjacent forestomach, the reticulum, the contents of which freely mix with those of the rumen. They dissolve very slowly and provide sufficient cobalt (between 0.1 and 1/0 milligrams per day) to meet the animal's requirements.

The C.S.I.R.O. Division of Biochemistry and General Nutrition has shown that cobalt acts by stimulating the growth of micro-organisms in the rumen which are capable of destroying the toxic material of Phalaris before it is absorbed into the animal. Very little cobalt is needed but to be effective the cobalt content of the rumen must not fall below a critical concentration.

Interim Formula

The "bullets" now available are made to C.S.I.R.O.'s Formula "A". They will provide the animal's requirements of cobalt for at least some months. Research is still in progress and more effective formulations may be evolved. The aim is to produce "bullets" that will remain effective for some years, if not for the life of the animal.

At present there is no certainty that all sheep will retain "bullets" in the rumen. The "bullets" may be dislodged and lost in about 5 per cent. of cases. This is of little consequence in most applications to correct cobalt deficiency since unprotected sheep can easily be detected and dosed again.

However, where protection against "phalaris staggers" is required, adequate warning of the

loss of the "bullets" will not be obtained and some sheep may become affected.

Formula "A" has been evolved for dosing sheep. It is not yet known whether it provides an effective means of supplying cobalt to cattle.

In large scale tests at least 93 per cent. of the treated sheep were protected from "phalaris staggers" under conditions in which between 30 and 60 per cent. of untreated sheep became afflicted by the malady and under which more would undoubtedly have been affected if they had not been withdrawn from the phalaris pastures.

Dow Chemical International Ltd. Appointment

Dow Chemical International Ltd. has appointed Mr. Joel H. Mace as resident sales supervisor for Australia and New Zealand.

In his newly-created position, Mr. Mace will assist Dow International's representatives in the area in merchandising Dow products—among which are plastics, agricultural chemicals and basic organic chemicals.

The appointment of a resident sales supervisor will establish better working contacts with representatives, distributors and customers in Australia and New Zealand and will give them better product service assistance.

Before assignment to this position, Mr. Mace was with United Development Corporation Pty. Limited in Sydney for six years. Born in Australia, he holds degrees in mathematics and chemical engineering from Melbourne University and economic science from Sydney University.

Dow International is a wholly-owned export subsidiary of The Dow Chemical Company of Midland, Michigan, a major American producer of chemicals.

Royal Australian Chemical Institute

Dr. I. W. Wark, Chief of the Division of Industrial Chemistry, C.S.I.R.O., has been elected General President of the Royal Australian Chemical Institute for 1957/58.

Dr. Wark has been Chief of the C.S.I.R.O. Division of Industrial Chemistry since its formation in 1940. Under his guidance this laboratory has grown until it now has a research staff of one hundred. It is one of the leading chemical research laboratories in the world.

Dr. Wark's own personal research was concerned with the theory of the flotation process for separating minerals from ores which is of major importance to mining industry. His pioneering work as a physical chemist in this field gained for him a world-wide reputation and his book, "Principles of Flotation", first published in 1938, became recognised as a classic on the subject.

First Honorary Fellow of R.A.C.I.

An American scientist, *Professor T. A. Geissman,* has been elected the first Honorary Fellow of the Royal Australian Chemical Institute.

Professor Geissman is in Australia to work for nine months on a Senior Fulbright Fellowship with the C.S.I.R.O. Division of Industrial Chemistry.

Professor Geissman is Professor of Chemistry at the University of California, Los Angeles. He is recognized internationally as an authority on the chemistry of plant constituents and will join the C.S.I.R.O. group working in this field.

New Wool Bureau Headquarters

The Prime Minister (Mr. Menzies) officially opened the Australian Wool Bureau's new headquarters, "Wool House", in Melbourne on Friday, September 27.

The building, a former warehouse, was bought by the Bureau in 1955 for £140,000 and has been remodelled into modern office accommodation totalling 39,000 square feet.

The Bureau has now centralized all its activities in one building in the business heart of Melbourne. Wool House accommodates the Bureau's publicity and promotion sections, the Wool Statistical Service and Wool Stores Administration.

Wool Promotion Activities

The wool promotion work of the Bureau is financed by a levy of four shillings on each bale of wool produced in Australia. During the current financial year it is expected that just over £1 million will be contributed to the overseas fund of the International Wool Secretariat by the Australian Wool Bureau.

The spending of funds on wool use promotion is concentrated overseas because these countries represent the major markets. It is expected that the International Wool Secretariat will spend £1¾ million on promotion during the current year.

Consolidation of Fragmented Holdings and Land and Water Use in Europe

European delegates to the Working Party on Consolidation of Fragmented Holdings met in Vienna (Austria) during October to discuss the problems of fragmentation in European countries and the technical, economic, social, legal and administrative aspects of land consolidation.

Land consolidation in Europe, in its broadest sense, does not imply only re-allocation of land, but includes the examination of all relevant social and economic aspects, including the re-organization of the farm units and the ways of re-adjustments of farm management and land use practices. One of the major items discussed was the problem of under-sized farms which presents great economic and technical difficulties to raising productivity and living standards in many rural areas throughout Europe.

The meeting of the Working Party on Consolidation of Fragmented Holdings was followed by the meeting of the Sub-Commission on Land and Water Use of the European Commission on Agriculture. It considered reports dealing with the problems of urban encroachment on good agricultural land; soil conservation and watershed management; and financial arrangements and administrative implementations of land and water development schemes. Information in the reports has been contributed by nearly all of the European countries.

The outcome of discussions and the information supplied by European member countries at the two meetings is being summarized in separate reports which will formulate recommendations to the governments concerned.

Marked Increase in Australian Broad Wools

Some interesting observations on wool production in Australia were made by Mr. R. B. McMillan, Executive Officer of the Australian Wool Bureau's Wool Statistical Service, when speaking at a course of lectures in wool commerce, held at the New South Wales University of Technology on 19th and 20th August. He was discussing "Changes in the Quality Composition of the Australian Wool Clip".

Mr. McMillan said that over the last four or five seasons there had been a spectacular rise in production of the broader merino wools, as well as in the finer crossbred categories.

This had to a great extent been due to the steady expansion in the volume of feed available, resulting from good seasons, the spread of pasture improvement, and the effects of myxomatosis.

The pattern had not been the same in all parts of Australia, as naturally both growing conditions and seasons show a wide variety from one end of the sheep belt to another. In the characteristically pastoral country of Queensland and N.S.W., while the trend had been towards the coarser end of the merino scale, in the more adverse seasons there has been a noticeable "fineing-up".

In Victoria and Tasmania, as well as in the safer rainfall areas of N.S.W. and South Australia, the trend has been for the baleages of both the broader merino and finer crossbred qualities to increase sharply, while output of other qualities has remained relatively stable. South Australia and Western Australia had presented rather complex patterns. The particular breeding lines on which merino production is based tend to show marked responses to seasonal conditions in the quality of the wool produced.

At the same time, production from their pastoral areas is static or declining, relative to the higher rainfall areas, some of which have experienced rapid expansion in recent years.

For the Australian clip as a whole, an interesting point was that although on a percentage basis the clip was tending to become broader, on a baleage basis, production of the finer qualities had been fairly well maintained.

Warning on Use of Organic Phosphorus Compounds for Treatment of Worms

C.S.I.R.O. is not yet able to recommend the organic phosphorus compound Neguvon for treating worm infestations in livestock.

Many new drugs which might be useful in the treatment of worm infestation have been tested by C.S.I.R.O. Recently at least one organic phosphorus compound was found to be promising. Unfortunately, many of these compounds are extremely poisonous but some of the less toxic ones, such as Malathion and Diazinon, are valuable insecticides.

The compound known as L13/59 or Neguvon shows promise for worm treatment but until further research has been done its use cannot be recommended.

In tests made at C.S.I.R.O.'s Veterinary Parasitology Laboratory at Yeerongpilly near Brisbane, it gave good results in removing worms from calves. Other tests at C.S.I.R.O.'s McMaster Animal Health Laboratory in Sydney have shown that it also has some effect on worms in sheep, but is less effective than phenothiazine against nodule worms and black scour worms in sheep.

As occasional deaths have occurred in treated calves and sheep, C.S.I.R.O. will not recommend Neguvon for treatment of worm infestations until further research has shown whether it can be used with safety.

International Botanical Congress

The Ninth International Botanical Congress will be held in Montreal, Canada, from August 19 to 29, 1959, at McGill University and the University of Montreal. The programme will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on programme, accommodation, excursions, and other detail will be available early in 1958. This circular and subsequent circulars including application forms will be sent only to those who write to the Secretary-General asking to be placed on the Congress mailing list.

Dr. C. Frankton, Secretary-General, IX International Botanical Congress, Science Service Building, Ottawa, Ontario, Canada.

Hydrogen Peroxide and Other Preservatives in Milk

A meeting of experts for the study of the use of Hydrogen Peroxide and other preservatives in Milk was held in Interlaken (Switzerland) from 23 to 27 September, and was sponsored by the Food and Agriculture Organization of the United Nations (FAO). This meeting, the first of its kind, was convened in response to a request from the Indian delegates and delegates from a number of other countries having hot climates, during a meeting organized by the International Dairy Federation (IDF) in September, 1956.

Most of the European countries are opposed to the use of hydrogen peroxide and other preservatives in milk. Their legislation rules that the use of such additives is fraudulent practice. They justify this rule not only on biological and hygenical grounds but also because most countries believe that such practices would annihilate efforts for a qualitative improvement of the milk. They feel that producers would not make any further effort to improve the quality of their milk if the use of preservatives was permitted.

In some Mediterranean countries there is a limited tolerance of the use of preservatives in strictly determined cases. Countries with tropical climates, considering their great difficulties in collecting, refrigerating, transporting and processing of milk, wonder whether the use of preservatives could not render great services to their new-born or newly developing industries.

The experts meeting at Interlaken examined this problem in an attempt to reconcile the two points of view. They studied the methods of efficient control of the use of preservatives in order to avoid mis-use involving risks for the consumer, and formulated recommendations which could eventually be taken into consideration by governments if the necessity of modifying existing legislation concerning the use of preservatives in milk should make itself felt.

Agricultural Notebook

Below is a list of chapter and section headings from the Agricultural Notebook edited by Dr. I. Molnar and a committee, with material from some 90 contributors. The manuscript is now completed and negotiations are in progress with publishers.

Climatology

Humidity: dry bulb; wet bulb; vapour pressure; saturation deficit; relative humidity; dew point; discomfort; evaporation; effective rainfall; evapotranspiration.

Frost: local prediction; frost prevention — heating, wind machine.

Rainfall: average annual rainfall; average monthly distribution; variability of rainfall; effective rainfall; influential rainfall.

Fertilisers and Soils

Fertilisers: phosphorus — superphosphate, rockphosphate; nitrogen — soluble forms, insoluble in water; potassium; trace elements; mixed fertilisers; lime and gypsum — lime, gypsum.

Soils: as sources of nutrients for plants; acid or alkaline; organic content; physical properties; field capacity, wilting point and bulk density; measuring soil-water in field; soil textures; mechanical analysis; salt; exchangeable cations; temperature; sampling soils for analysis; glossary of terms; further reading.

Soil Microbiology

Types and Numbers of Micro-organisms in the Soil.

Activties of Soil Micro-organisms: decomposing dead organic substance; physical condition of soil; nitrogen fixation; ammonification and nitrification; soil nitrogen cycle; other activities.

Soil Erosion

Types of Erosion and Their Causes: sheet erosion; rill erosion; gully erosion; tunnel erosion; stream erosion; siltation; drift sand.

Treatment of Erosion: wind erosion; water erosion.

Particulars of Erosion Control.

Pastures

Area of Pasture Land Top-Dressed with Fertiliser.

Pasture Seed Production—1955/56.

Certified Seed Production—1955/56.

Principal Characteristics of Pasture, Fodder and Lawn Grasses Sown in Australia.

Principal Characteristics of Pasture and Fodder Legumes Sown in Australia.

Germination, Seed Size and Establishment of Pasture and Forage Grasses.

Germination, Seed Size and Establishment of Pasture and Forage Legumes.

Economic Aspects of Seed Purchase.

Nutritional Deficiency Symptoms in Subterranean Clover.

Nutritive Value of Pastures.

Fungus Diseases of Pastures.

Insect and Mite Pests of Pastures.

Plant Ecology and Its Terminology.
Characteristics of Distinct Varieties of Pasture Plants Listed by Australian Seedsmen.
Seed Certification.
Floral and Vegetative Characters of Various Pasture Plants.

Crops

Conversion Factors.
General Notes on Cereals: cereal seed; vegetative structure; leaf; inflorescence; spikelet; flower; time of sowing for grain crops; seeding rates; time of harvest; fertiliser treatment.
Wheat: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; insect pests and diseases; cultivation method; harvesting; marketing; quality; the regulation of Australian wheat trade; payments to wheat producers; bulk wheat storage; main regions of production in Australia; world statistics; references.
Rye: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; cultural method; uses; marketing; main regions of production; world statistics.
Barley: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; diseases; cultural methods; harvesting; uses; marketing; main regions of production; world statistics.
Oats: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; diseases; cultural methods; harvesting; uses; marketing; regions of production in Australia; world statistics.
Rice: general description; cultivated types; cultural methods; harvesting; uses; marketing; main regions of production—the N.S.W. rice industry, rice in Northern Australia; world statistics.
Maize: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; other maize types; pests and diseases; cultural methods; harvesting; uses; seed maize; marketing; main regions of grain production; world statistics.
Sorghum: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; insect pests and diseases; cultural methods; harvesting; uses; sorghum poisoning; marketing; main regions of production in Australia; world statistics.
Millets: species; Australian acreage and yield; vegetative structure; commercial varieties in Australia; cultural methods; harvesting; uses; marketing; main regions of production in Australia; world statistics.
Sugar Cane: origin; Australian acreage and yield; vegetative structure; cultivated species; harvesting; after harvest treatment of "plant" crop; insect pests and diseases; payment to growers; processing; marketing; the world sugar situation in relation to exports; net titre and coefficient of work; refining; main regions of production in Australia; world statistics.
General Notes on Pulse Crops.
Field Peas: Australian acreage and yield; cultivated species; commercial varieties in Australia; insect pests and diseases; cultural methods; dry seed classification and use; processing; marketing; main regions of production in Australia; world statistics.
Peanuts: Australian acreage and yield; general description; cultivated species; commercial varieties; insect pests and diseases; cultural methods; harvesting; marketing; main regions of production in Australia; world statistics.
Cruciferous Crops: species; uses; morphology of the cabbage group; diseases.
Oil Crops: importance; chemical characteristics; general description; characteristics of annual oil seed crops; commercial features of annual oil seed crops.
Flax and Linseed: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; insect pests and diseases; cultural methods; harvesting; uses; marketing; main regions of production in Australia; world statistics.
Cotton: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; insect pests and diseases; cultural methods; harvesting; marketing; main regions of production in Australia; world statistics.
Potato: Australian acreage and yield; general description; cultivated species; commercial varieties in Australia; insect pests and diseases; potato seed certification; cultural methods; harvesting; marketing; main regions of production in Australia; world statistics.
Tobacco: Australian acreage and yield; description; cultivated species; commercial varieties in Australia; cultural methods; methods; harvesting; marketing; main regions of production in Australia; world statistics.
Hops: Australian acreage and yield; general general description; cultivated species; commercial varieties in Australia; cultural methods; harvesting; marketing and use; main regions of production in Australia; world statistics.

Fruit Crops

Some Practices: grafting; shield budding; systems of tree planting.
Fruits: almonds; apples; apricots; avocado; bananas; berry fruits—loganberry, gooseberry, currants, raspberry, strawberry; cherries; citrus fruit; custard apples; figs; grape vines; macadamia nut; mango; olives; passion fruit and granadillas; pawpaw (papaya); peaches and nectarines; pears; pineapples; plums and prunes; quinces; walnuts.
Cold Storage of Fruits and Vegetables.
Miscellaneous; approximate bushel weights; standard sizes of fruit cases; fresh and dried fruit relationships; fresh and canned fruit relationships; grape-vine relationships; exports of canned fruit; exports of fruit juices.

Pests and Diseases in Fruit Crops and Chemical Control of Weeds

Insect and Mite Pests: insect and mite pests and their control; insect pests of the orchard; insect pests of vegetables; tobacco pests.
Diseases: plant diseases and their control; citrus fruit—fungus diseases, virus diseases; fungus diseases of pome fruit; stone fruit—fungus diseases, bacterial diseases, virus diseases; fig; vines; tropical fruits—bananas, passion fruit, mangoes, pawpaws, pineapples; berry fruits—fungus diseases, virus diseases.

Chemical control of Weeds: weeds and weed control; recommendations for control of more important broadleaf weeds; control of woody perennials, trees, suckers and scrub; non-selective weedkillers; table of agricultural chemicals in common use throughout Australia.

Sheep and Fat Lambs

General: terminology; points of a sheep statistics.

Sheep: principal breeds of sheep in Australia; puberty; oestrus; gestation periods; mating periods—availability of green feed, conception; ewe: ram ratio; "flushing"; lambing results.

Management: mob size; labour requirements; flock composition—the breeding flock; culling percentages, total flock numbers; grazing management; grazing or feeding efficiency; flock management at lambing time; age identification; lamb marking—castration, tailing, ear marking; problems with weaners; care of the ram flock; branding; shearing and wool classing—dates of shearing, shearing shed practice, shearing tallies, wool classing.

Fat Lambs: breeds; the ewe; the ram.

Management: availability of pasture; time of mating; lambing percentage and lamb loss; general characteristics; mob size; husbandry—before mating ("flushing") and during pregnancy, after lambing. after lamb sales.

Marketing: auction sales; paddock sales; sales on a weight and grade basis.

Diseases.

Cattle

General: terminology; points of cattle; statistics.

(1) *Dairy Cattle.*

Statistics.

Principal Breeds of Dairy Cattle in Australia.

Vital Characteristics of Dairy Cattle and Herd.

Management: herd size; calves; dairy herd; grazing—intermittent grazing, controlled grazing, strip grazing; fluctuations in feed supply; milking—shed design, milking time and routine.

Production of Clean Milk: source of contamination; measures for the prevention of defects in quality—training of the milker, buildings and equipment, water supply, milking shed practice, cooling the milk, washing and sterilising milk plant and utensils—(a) a water heater (b) cleaning compounds, bulking milk, sterilisation of bottles and cans, control of taints and flavours—(a) feed taints (b) absorbed flavours (c) other taints, abnormal cows.

(2) *Beef Cattle.*

Statistics.

Distribution.

Principal Breeds of Beef Cattle in Australia.

A. *In Northern Australia*: number of bulls; time of mating; calving; management; growth rate—British breeds—on native pastures, on improved pastures, on improved tropical pastures, on oats—crosses between British and Brahman breeds.

B. *In Southern Australia.* C. *Diseases.*

Pigs

General: terminology; points of a pig; statistics; principal breeds of pigs in Australia.

Pig Keeping Systems: extensive; semi-intensive; intensive.

Area and Site Requirements.

Size and Arrangement of Paddocks.

Housing Requirements: farrowing pens; feeding pens; trough space; house temperature.

Breeding Methods: weight and age of the sow; puberty, oestrus and gestation; planned farrowing (litter systems); the age of the boar.

Management: the period from mating to farrowing; from farrowing to weaning—methods of weaning, growth rates, quality considerations.

Marketing: auction sale; per lb. dressed weight; on the farm.

Diseases.

Poultry

General: terminology; points of a bird; principal breeds in Australia; criteria of production;

Space Recommendations: chickens; laying birds—floor space, feeder space, distance of feeder to waterers, water space, roost space, nest space.

Hatching: timing; number of eggs; incubation.

Sexing: vent sexing; "machine sexing"; sight sexing on down colour.

Brooding Equipment.

Housing of Laying Birds.

Management: chickens; laying birds—size of flock, artificial lights, litter, hen: cockerel ratio, confinement.

Diseases and Disorders: disease prevention; medicated feeds; anti-coccidiosis feeds; antibiotics; de-worming feeds; control of external parasites; cannabalism and feather picking; nutritional disorders (see under "feeding").

Horses

Terminology.

Colours and Markings: colours; markings.

Points of a Horse.

Statistics.

Principal Breeds of Horses in Australia.

Breed Societies.

Breeding Methods: puberty; oestrus; gestation period; mating period; foaling.

Rearing and Management.

Work.

Age Identification.

Shoeing.

Marketing: thoroughbred yearling sales; auction sales; exports.

Diseases and Defects: strangles; worms; wounds and infections; tetanus; colic; teeth.

Hereditary Unsoundnesses.

Livestock Breeding

Fundamentals of Animal Breeding: introduction; definition of aims; principles of genetics—cell structure and division, genes as the basis of inheritance, genotypic variation, gene action and interaction, inheritance of quantitative characters, correlation between characters, gene x environment interactions; selection—selection of (a) strain or breed and (b) individual, how selection works, selection for lifetime performance, selection for improvement of future generations; mating plans—classification of breeding plans, inbreeding, random mating, line-breeding, systems exploiting heterosis—cross-breeding and line- or strain-crossing.

Merino Sheep Breeding: economic characters; selection and mating plans—criteria for selection, aids to selection, a flock improvement plan, results of breeding projects; inbreeding—general effects, use of inbred lines; cross-breeding; genes

and their action; breed societies; further reading.

Breeding of Sheep Other Than Merino: economic characters; selection — criteria for selection, aids to selection; inbreeding—general effects, use of inbred lines; cross-breeding; known genes; breed societies; further reading.

Dairy Cattle Breeding: economic characters and selection; inbreeding and outbreeding; cross-breeding; genes and their action; official improvement schemes: breed societies; practical improvement plan; further reading.

Beef Cattle Breeding: economic characters—in the harsh northern environments, in temperate environments; heritability of colour; inbreeding; cross-breeding; methods of improvement; lethal characters; further reading.

Pig Breeding: economic characters; selection; inbreeding; cross-breeding; genes and their action; official improvement schemes; breed societies; further reading.

Poultry Breeding: economic characters; selection—mass-selection, practical plan to improve egg production; inbreeding; cross-breeding; genes and their action; official improvement schemes.

Livestock Feeding

Scientific Basis of Feeding and Terminology.

Chemical Analyses and Food Values of Various Foodstuffs.

Digestion.

Vitamins: vitamin B group and protein synthesis in ruminants; carotene and vitamin A; vitamin D.

General: Antibiotics in stock rations; recommendations for the grinding of common grains and roughages; average daily water requirements and safe upper limits of total salt in water for stock; relative costs of fodders; economics of drought feeding.

Feeding Sheep: maintenance fodder requirements; feeding on pasture—sheep, lambs; supplementary feeding—before mating and during pregnancy, during diminishing pasture feed; effect of supplementary feeding; complete hand-feeding; starting hand-feeding; periodic feeding; early weaning of lambs in drought; mortality after drought.

Feeding Cattle.

(1) *Dairy Cattle*: feed requirements; cows—feeding on pastures, supplementing pasture feed; wholly hand-fed and housed dairy cattle; calves—rearing in the first week, second week onwards to weaning, weaning.

(2) *Beef Cattle*: feeding standards; feeding on pastures; supplementing pasture feed.

Feeding Pigs: nutrient allowance; vitamin requirements; ration requirements and growth rates; feeding of breeding stock; composition of ration for pigs of different stages of growth and live weights; pig-grain ratio; a specimen ration; substitutes for barley in the ration; substitute for lime-salt mixture; salvage products; bulky feeds and self feeders; efficiency.

Feeding Poultry: food requirements; methods of feeding; rations; feed consumption and growth rates—feed consumption of chickens, approximate growth rate and feed consumption of pullets; approximate feed requirements of layers; sample rations for chickens for six weeks to maturity and for laying stock; broilers; symptims of nutritional deficiencies.

Feeding Horses: feed requirements; rations.

Wool

Quantity of Greasy Wool Sold at Auction.

Fleece Fibre: classification; evolution.

Spinning Quality: definition and terminology; relation to woollen and worsted yarn manufacture; quality numbers; staple length; yield; colour; soundness; style.

Wool Classing.

Glossary.

World Statistics.

Australian Wool Statistical Service.

Dairy Products

Statistics.

Milk: Composition of milk—overseas figures for breeds common in Australia, Australian figures, the physical structure of milk, variations in fat content of milk, effect of stage of lactation, the proteins of milk, fatty acid composition of butterfat, composition of the mineral matter of cows' milk; production of milk—variations in monthly production of milk for each State; milk products—composition of milk products, State and Federal compositional standards, milk products and their manufacture, classification of types of cheese, utilisation of milk in Australia; milk products in the diet—annual per capita consumption, contribution of dairy products to Australian diet, composition of products from the nutritional viewpoint, value of dairy products as stock feed.

Miscellaneous Data: temperature requirements for storage; specific gravities and weights per gallon; calculation of solids of milk; grading of dairy products.

Notes: keeping milk out after calving or udder treatment; acidity in milk; fat losses in separating; overrun in buttermaking; test for added water; cleansing and sterilisation; the determination of bacteria in milk; sediment test; Babcock test; copper in dairy products, light on milk; weed taints; trade weights and dimensions.

Reference Books and Journals.

Meat

Statistics.

Meat in General: ratio of fat to protein; loss in weight of the carcase during transport of an animal without food and water; keeping qualities of meat; post mortem changes in meat; changes in freezing; curing of meat.

Beef: carcase grades; cuts of beef; cuts of veal; estimation of carcase composition; calculated composition of carcases; degree of fatness; carcase appraisal; edible offals.

Lamb and Mutton: carcase grades; dressing percentage; cuts of lamb and mutton; carcase composition; fat lamb carcase appraisal

Pig Meats: carcase grades; cuts of pork; carcase composition; carcase appraisal.

Poultry.

Eggs.

Hides and Skins

Statistics.

Hides and Skins: introduction; care of living animals; flaying; care and preservation of the skin; wild animals; transport; further information.

Weights and Yields: sheep skins; wet salted cattle hides; rabbit skins (dry).

Food Inspection in Australia

Inspection of Foodstuffs for Export: dairy produce; fresh fruit; fresh vegetables; canned and frozen fruits and vegetables; dried fruits; general exports; flour; fish; general.

Inspection of Foodstuffs for Local Use.

Farm Machinery

Units of Force, Torque, Energy and Power: force; torque; mechanical energy or work; power; horse power; dynamometers; other units of energy; efficiency.

Piston Type Internal Combustion Engine: description—2 stroke engine, 4 stroke engine; operation—valve timing, admission of new charge, carburettors, ignition, ignition timing, fuel injection, the diesel principle, hot spot, semi-diesel engines, compression ratio, knocking, octane rating, control of engine output, governed engines, efficiency and engine losses, cooling, variation of torque, flywheel, firing order, starting internal combustion engines, crankcase dilution, exhaust gases, spark arrester, fuels; performance—torque/speed characteristics, power/speed characteristics, definitions.

Tractors: descriptions — tractor—definition, industrial tractor, agricultural tractor, tractor engines; tractor output—drawbar work, belt work, power take-off work, hydraulic work; track performance—belt performance, P.T.O. performance, drawbar performance, suggested field performance, economy in drawbar working; traction—thrust or traction, effect of weight, traction failure and traction aids, wheel slip, rolling track or tractive resistance, weight transfer, tractor or 3-point linkage; tractor testing—purpose, testing authorities and the status of tests, formal testing, schedule of tests (Australian), interpretation of tests for field performance, summary of Australian tractor tests, Nos. 2-27; tractor stability and safety—tractor stability, static instability, dynamic instability, alleged safety devices and warnings, precautions.

Farm Plant and Machinery: engineering definitions; field machinery—width, speed and area of work, draught (or pull) and power to work machines, speed of field machinery, draught of implements and machines, matching tractors to implements, operation and control of plant and machinery; cultivation—preparation of the soil—cultivation, or tillage, plough, multi-furrow ploughs, tractor attached ploughs, reversible ploughs, side-draft, mouldboard plough, disc ploughs, cultivating, disc plough or disc cultivators, tined implements, other weeding tools, trash-farming — cultivating — tilling — ploughing, cultivation and soil tilth; sowing and planting, fertilising and intercultivation—drill, broadcaster, maize (corn) planter, potato planter, transplanter, inter-cultivation; crop harvesting—mower, reaper and binder, stripper, reaper-thrasher, header-harvester, combine-harvester, machinery for fodder conservation, harvesting pasture seeds, harvesting of vegetable, row and underground crops; other field machinery—pest and disease control, irrigation equipment, drainage equipment, erosion control equipment, clearing and earth moving machines; farm dairy equipment—milking machines, milk cooling, cream separator; shearing equipment—shearing plant, wool press; fruit grader; driers.

Pumps: kinds of pumps—positive displacement pumps, pressure raising pumps; descriptions; pump hydraulics; air pumps.

Irrigation

Statistics.

Water Used for Irrigation in Australia: water resources—surface water, underground water; definition of terms; measurement of irrigation water—units of water measurement, weirs, submerged orifices, Dethridge meter, approximate yield of spring or stream; water distribution—ditches, flow in pipes, irrigation farm structures; chemical weed control in channels and drains; land preparation for irrigated pastures—horsepower requirements, suitable plant for contract work, suitable plant for farmer, unit costs for land preparation; water quality—boron toxicity, salinity of Murray River, tolerance of crops to salt; irrigation methods—flooding, border check, contour method, contour check systems, border check method, furrow irrigation, spray irrigation; irrigation and type of farming—considerations, water required by various crops; calendars of operations.

Farm Tree Planting

Major Factors.

Points in a Tree Planting Programme.

Further Information.

Rabbits

History: movements and migration.

Living Habits: drinking and feeding habits; reproduction; natural mortality, predators, parasites and disease.

Economic Importance: the rabbit as a competitor for pastures and crops.

Control: legisation for control; the possibility of control and eradication; the strategy of eradication—encirclement—netting fences, main attack.

Miscellaneous

Tenure of Land: types of tenure; share farming agreements—cereal farming, dairy farming.

Land Classification.

Glossary of Some Economic Terms.

Farm Credit.

Interest Rates.

Insurance.

Land Values.

Systems of Farming.

Farm Costs and Farm Incomes.

Relation of Capital Expenditure to Depreciation and Taxation.

Wages and Costs.

Efficiency in the Use of Agricultural Machinery.

Fencing.
Fodder Conservation: types of conservation; measurement of hay and straw stacks.
Marketing: the Commonwealth constitution; Commonwealth marketing organisations.
Immunity and Antibiotics.
Agricultural Colleges.
Centres of Research and Investigation.
Stock Equivalents of Grazing Animals.

Mensuration

Imperial Weights and Measures.
Metric Weights and Measures.
Weights and Measures of U.S.A.
Conversion Factors.
Water.
Timber.
Units of Farm Commodities.
Building Materials.
Other Liquids.
Areas and Volumes.
Livestock.

BOOK LIST

Notice has been received that the following books on agricultural topics have been published recently:—

CUNHA, Tony J.—Swine feeding and nutrition. *New York, Interscience Publishers,* 1957, 64/3.

FOLLEY, S. J.—The physiology and biochemistry of lactation. *Edinburgh, Oliver and Boyd,* 1956, 25/-.

HARTMAN, R. C., and KING, D. F.—Keeping chickens in cages. *Mt. Morris (Illinois), Watt Publishing Co.,* 1956, $5.25.

INTERNATIONAL WORKSHOP ON FARM MANAGEMENT, Bonn. — Farm management: a summary of papers read at the International Workshop . . . 8-13 June, 1953, price not known.

MELBOURNE UNIVERSITY.—A field performance of hay-making machinery: a field survey in Victoria in the seasons 1954, 1955, 1956. May, 1957.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION.—Control of Johne's disease in cattle, sheep and goats. *Paris,* 1956, 12/- stg.

RIVER MURRAY COMMISSION.—Report on the River Murray flood problem, 1957, 10/-.

ROWE-DUTTON, Patricia.—The mulching of vegetables. *Farnham Royal, C.A.B.,* 1957. (Commonwealth bureau of horticulture and plantation crops, Tech. Comm. 24), 20/- stg.

SHEEHY, E. J.—Animal nutrition. *London, Macmillan and Co.,* 1955, 49/9.

SYDNEY UNIVERSITY, Dept. of Agricultural Economics.—Mimeographed report No. 1—Economic aspects of the association of beef cattle with sheep production, Part 1. The New England Region of N.S.W. 1957, free.

SYDNEY UNIVERSITY, Dept. of Agricultural Economics.—Research Bulletin No. 1—Social factors in serrated tussock control. A study of agricultural extension. 1957, free.

U.S. DEPT. OF AGRICULTURE.—Technical Bulletin 868—a monographic study of bean diseases and methods for their control. Revised, February, 1957, 60 cents.

UTAH AGRICULTURAL EXPERIMENT STATION, Logan.—Bulletin 384—Virus and virus-like diseases of stone fruits in Utah, 1957, $1.50.

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Applications are invited from young men, preferably with pastoral and agricultural training in Queensland and New South Wales for an administrative position in a large Pastoral Company stationed in Melbourne.

Age: Between 30 to 35 years.

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Other Conditions: Three weeks' annual leave. Provident Fund and Sickness Benefits Scheme available after qualifying period of service. Successful applicant would be required to visit New South Wales and Queensland Stations as may be necessary.

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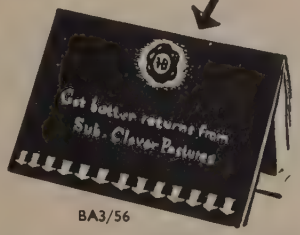

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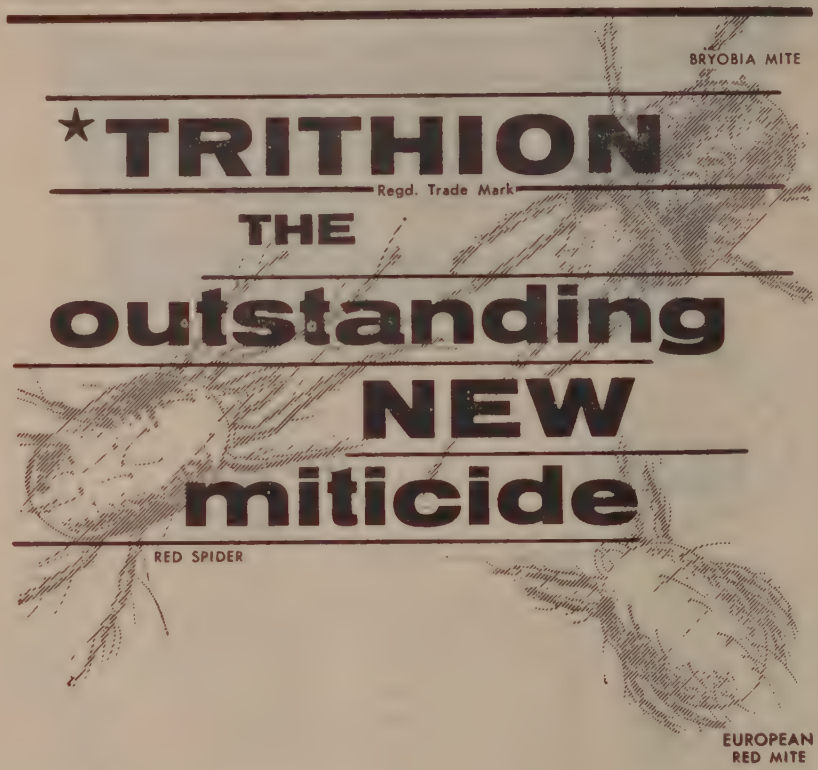

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PERSONAL NOTES

Australian Capital Territory

Mr. J. A. Carnahan, who will be stationed at Canberra, is to study ecological aspects of competition between pasture species and weeds. He is a graduate of Auckland University College and has for a number of years been a lecturer in ecology and botany at Massey Agricultural College. He has also been investigating indigenous and introduced weed species of New Zealand, particularly those of unploughable sown pastures. He arrived in Australia early in December.

Mr. T. P. Palmer, geneticist from the Crop Research Division, D.S.I.R., New Zealand, spent a week at the Canberra laboratories discussing the work of the Division. He is in Australia studying aspects of plant breeding.

Mr. F. C. Crofts and a party of agricultural students from Sydney University spent a day at the Canberra laboratories and Dickson Field Station. The group were shown the work being done on pasture utilization and pasture ecology.

Dr. D. E. Tribe, School of Agriculture, Melbourne University, spent several days in Canberra discussing the work of the Division. He will be visiting Canberra during November with a party of agricultural students.

Dr. L. A. T. Ballard, who is to leave for America in October, has been granted a Research Scholar Fulbright Travel Grant. Dr. Ballard will spend approximately 10 months working in Professor K. C. Hamner's Laboratory, Department of Botany, University of California.

Mr. J. A. Zwar left Sydney on the 6th August to take up a research assistantship with Professor Skoog, Department of Botany, University of Wosconsin. Mr. Zwar has also been awarded a Fulbright Travel Grant.

Dr. J. V. Possingham, who has been studying plant nutrition at the University of Oxford, has been awarded a Rockefeller Travel Grant. This will enable him to visit research centres in North America before returning to the Division in October of this year.

New South Wales

Dr. R. J. Noble, Under Secretary and Director of the N.S.W. Department of Agriculture, joined the Australian Delegation attending the Food and Agricultural Organisation conference in Rome during November. Dr. Noble will visit Switzerland, France, Holland, Denmark and England.

Mr. L. J. Lynch, of the C.S.I.R.O., Homebush laboratories, is in Hawaii as Acting Director of the Food Technology Laboratories in the College of Agriculture, University of Hawaii. Mr. Lynch left Australia in September and will be returning in June, 1958.

Dr. B. G. Davey returned to Sydney in August after spending three years at the Macawley Institute, for Soil Research, Aberdeen, Scotland. Dr. Davey was awarded his degree by the University of Aberdeen, for his studies of the seasonal distribution of trace elements in pasture herbage species. As well as these studies, which were made with the assistance of a Thomas Lawrence Pawlett Scholarship, Dr. Davey studied soil-advisory methods in the Continent and Great Britain and he has now returned to the Soil Survey Unit, N.S.W. Department of Agriculture.

One of the technical experts accompanying the President of South Vietnam in his visit to Australia in September was *Mr. Lamvanvang,* Director of Research in Agronomy, Forestry and Animal Husbandry in the Ministry of Agriculture. Mr. Lamvanvang made a brief study of food processing establishment whilst in Sydney.

Mr. H. E. Lea returned to Sydney after a six months' visit to U.S.A. and Canada, investigating the latest methods of tobacco research. Mr. Lea spent considerable time at the Raleigh State College, North Carolina, one of the leading research centres in U.S.A.

Victoria

Dr. D. B. Williams recently took up his new appointment as head of the Research Liaison Section of C.S.I.R.O. in Melbourne.

Mr. K. L. Avent of the Victorian Department of Agriculture has been appointed Manager of Tatura Horticultural Research Station, Tatura, Victoria.

Queensland

The Degree of Doctor of Agricultural Science has been awarded to *Dr. P. J. Skerman,* Senior

Lecturer in Agriculture at the University of Queensland, for a thesis and supporting papers concerning the potentialities of Queensland. His thesis dealt with the Channel Country and was supported by published papers and maps dealing with Queensland Land Use, Queensland's Soils, the Mareeba-Dimbulah Irrigation Project, the Darling Downs, Underground Water in S.E. Queensland, the Brigalow Country, the Central Highlands, and the Burdekin Valley. Papers on Cropping for Fodder Conservation in the under 20 inch rainfall sheep areas of the State, and the Anglo-Australian Rice Mission's Report on Increasing Rice Production in Ceylon were also included.

Dr. F. K. van de Kley has joined the C.S.I.R.O. Plant and Soils Laboratory, Brisbane, as a Research Officer, working on pasture ecology in sub-tropical Queensland. Dr. van de Kley has worked on pasture agronomy and pasture utilization at Wageningen, Netherlands, and visited the Grassland Research Institute, Hurley, England, before coming to Australia.

Mr. John Wolfe, of the Department of Agriculture and Stock, left for nine months' study at Cornell University, on September 11th. Mr. Wolfe, who has obtained a Commonwealth Extension Services Grant, is to study for the Master of Science degree, majoring in Extension Education.

Mr. Dick Hewetson has recently transferred from the C.S.I.R.O., Armidale, to the National Cattle Breeding Station, Belmont, and is now a member of the Queensland Branch of the Institute.

Mr. Norm Shaw will be leaving Australia in January, 1958, on a visit to South and East Africa. The trip will include visits to the Union of South Africa, the Federation of Rhodesia and Nyasaland, Tanganyika, Uganda and Kenya and will last about five months. The main object is to study research on pasture management and development of sown pastures.

Professor Teakle's Visit to Madagascar

The Australian Academy of Science appointed *Professor L. J. H. Teakle* one of the six Commonwealth delegates to attend the Third Pan-Indian Ocean Science Congress held in Madagascar from October 24th to November 5th, 1957. Other members of the Australian delegation were *Professor A. D. Ross* (W.A.), Leader; *Professor S. W. Carey* (Tas.); *Dr. E. P. Hodgkin* (W.A.); *Professor J. C. Jaegar* (A.C.T.); *Dr. G. F. Humphrey* (C.S.I.R.O.).

The party left by air from Sydney on 19th October, returning on 21st November, 1957. At the Congress, Professor Teakle presented a paper entitled "The Road Ahead for Australian Agriculture."

F.A.O. Fellow Arrives in Queensland

Mr. K. W. Harker, Pasture Agronomist with the Government Veterinary Department of Uganda, is at present visiting Australia and New Zealand on an F.A.O. Fellowship. Mr. Harker, who is a graduate of Leeds University, is in charge of grassland advisory work for the whole of Uganda and pasture research work at Entebbe. In Australia he intends to study the utilization of both native and sown pastures.

Mr. Harker arrived in Brisbane on the 7th October after spending a few days in Canberra. For a period of 9 or 10 weeks he will be based on the Plant and Soils Laboratory, from which he will visit Department of Agriculture Stations in North Queensland, and the C.S.I.R.O. stations at Katherine and Belmont. After leaving Queensland, his itinerary will include Sydney, Deniliquin and Melbourne, and then New Zealand, before returning to Uganda.

Overseas Studies on Fruit Fly Control

Mr. A. W. S. May, Senior Entomologist, Department of Agriculture and Stock, Toowoomba, is to make a four months' study tour of Hawaii and the U.S.A. next year to examine American progress on fruit fly control.

The decision to send an entomologist on the study tour followed a recommendation from the Australian Agricultural Council supporting a proposal put forward recently by a conference of State and Commonwealth entomologists. The Department of Primary Industry will meet the costs of the tour.

Mr. May, who is regarded as one of Australia's most experienced workers on the fruit fly problem, will make a special study of insecticidal control, eradication methods and commodity treatment and on his return will continue with his own work in Queensland and will be available for consultation with entomologists from other States.

South Australia

South Australian Institute members learnt with deep regret of the death of Mr. H. E. Orchard, Weeds Research Officer of the Department of Agriculture, on October 28. His car overturned near Jamestown when he was on his way to deliver a lecture. Mr. Orchard was an

acknowledged authority on weed problems and he will be a great loss to agriculture in South Australia, as well as a personal loss to his colleagues. The Institute extends its deep sympathy to his relatives and friends.

Dr. Millington was awarded his Ph.D. degree by the University of Adelaide in October.

Mr. Rankine is with the Oenology Department at the University of California.

Mr. Rajbhandary sailed from Adelaide for India in September after 3½ years with the Agronomy Department at the Waite Institute.

Dr. N. Flentje returned to Adelaide on 4th August after a period of study leave in America and the United Kingdom. At the moment he is Acting Head of the Department of Plant Pathology at the Waite Institute.

Western Australia

Mr. R. F. Doepel, Plant Pathologist, returned from England on September 15th and has resumed duties with the Department of Agriculture. While in England, Mr. Doepel investigated some of the latest techniques in plant pathology work and was able to visit research centres at East Malling and Rothamsted and others in Scotland and Northern Ireland.

Mr. J. A. Parish, an Adviser in the Cereal Laboratory of the Department of Agriculture left in September to visit some of the principal centres of cereal research in New South Wales and Victoria. These include the Bread Research Institute in Sydney, the Wagga Agricultural Research Institute and the Cereal Laboratory of the Victorian Department of Agriculture, as well as some of the large bakeries and biscuit manufacturers. Mr. Parish expects to return to Perth in mid-December.

Mr. J. L. McMullan, a Soil Conservation Adviser in the Department of Agriculture, has been transferred from the Perth office to the regional office at Geraldton. His work will include investigation associated with the stabilisation of coastal sand dunes in the area.

Mr. S. E. Hardisty, Adviser in the Horticultural Division of the Department of Agriculture, has been appointed District Officer at Bridgetown.

Mr. P. D. Ramm, who was previously Assistant to the Animal Nutrition Officer in the Department of Agriculture, has now taken up an appointment with the Department of Agriculture at Rabaul, New Britain.

Mr. I. McL. Eadie, a former member of the Victorian Branch has transferred to Perth where he has the position of Technical Adviser in the Biological Division of I.C.I.A.N.Z.

Mr. D. Fisher, an officer with the Rural & Industries Bank of W.A., has been transferred from Bunbury to the Perth office.

Mr. M. G. Hawson, who has been with the Department of Agriculture at Alor Star, Kedah, Malaya, for some time, is back in Perth for a short holiday, before taking up an appointment in New Guinea.

Mr. T. Pavy, previously an Adviser in the Dairy Division of the Department of Agriculture, has accepted an appointment at Groote Eylandt. As a Staff Worker with the Church Missionary Society, Mr. Pavy will be in charge of all the agricultural work, both practical and teaching, on the island.

Messrs G. H. Burvill, Chief Plant Research Officer, *L. C. Lightfoot,* Superintendent of Soils, both of the Department of Agriculture, *Mr. J. Mulcahy,* Regional Officer, Soils Division, C.S.I.R.O., and *Dr. D. P. Drover,* Senior Lecturer in Soil Science at the University of Western Australia, attended the Second Australian Conference in Soil Science, held in August at the University of Melbourne.

Mr. P. Brisbane is now living in New South Wales, where he has a position in the Department of Agriculture.

Mr. A. G. Turton, of the Soils Division, C.S.I.R.O., has been seconded for twelve months to the Iraqi Development Board in Bagdad. He is to take charge of a laboratory carrying out soil analyses related to surveys associated with work on new and rehabilitated irrigation schemes.

Dr. D. P. Drover has recently been appointed as Senior Lecturer in Soil Science at the Institute of Agriculture, University of Western Australia.

Mr. H. E. Fels has taken up a position in the Animal Division of the Department of Agriculture, as Assistant to the Animal Nutrition Officer.

Mr. B. Truscott, who has been an Agricultural Adviser with Cuming Smith & Mount Lyell Farmers' Fertilizers Ltd., has resigned from this firm to accept a position as Science Liaison Officer in the Rural and Research Department of the Commonwealth Bank in Sydney.

Mr. F. M. V. Knapp of Darkan was again prominent at the Claremont Showground during Show Week, when he officiated as one of the judges for the popular sheep dog trials.

Mr. R. A. Pearse after spending some time in England was in Perth for a few weeks before proceeding to New South Wales, where he has a position as an Agricultural Economist in the Division of Marketing and Agricultural Economics, Department of Agriculture.

Mr. P. L. Stallwood, a Research Officer in the Research Division of the Department of Agriculture, has resigned to take up duties with the Department of Agriculture of Papua and New Guinea.

BRANCH NOTES

Australian Capital Territory

At the 132nd Branch meeting, on 8th August, the President, *Dr. D. B. Williams*, was in the Chair and 80 members and visitors were present. The President welcomed Wool Extension Officers and Department of Agriculture Plant Breeders who were attending schools in Canberra.

The President introduced *Mr. C. C. Corbett*, who described the projected use of the Snowy Mountains water by the N.S.W. Government. Mr. Corbett outlined the history of the idea, the advantages of the scheme and defined the requirements for a successful irrigation area. He explained the reasons for the choice of certain areas in N.S.W. for irrigation settlements and mentioned that projects other than those concerned with the use of the Snowy waters would also be continued.

A considerable number of questions followed the address.

The 133rd General meeting on 19th September was addressed by *Professor J. S. Turner*, Professor of Botany, University of Melbourne, on grazing in the Snowy Mountains.

New South Wales

A general meeting of the Branch was held on the 27th September at the School of Agriculture, University of Sydney. The main business of the evening was an address by Dr. J. N. Gregory, Chief of the Radio Isotopes Division of the Atomic Energy Commission, entitled, "The Use of Radio Active Isotopes in Agriculture and Industry." Dr. Gregory's presentation of this most interesting subject stimulated considerable discussion on the possible application of isotopes in wide and varied fields of research.

A symposium entitled "Drought Mitigation", arranged jointly by the N.S.W. Branch and the "Men of the Land" Society, was held at Science House on October 31st. The symposium consisted of an afternoon and evening session and a buffet tea. The Rt. Hon. Sir William McKell, G.C.M.G., P.C., President of the "Men on the Land" Society, opened the symposium at 3.30 p.m. and was chairman of the afternoon session. Speakers at this session were Professor R. D. Watt, Emeritus Professor of Agriculture, The University of Sydney, Mr. C. C. Corbett, Chief Commissioner, Water Conservation and Irrigation Commission, and Mr. A. J. McIntyre, Chief Liaison Officer, Rural Liaison Service, Commonwealth Bank of Australia. The President of the N.S.W. Branch, Dr. R. L. Reid, was Chairman for the evening session at which the main speakers were Mr. B. H. Harris, Agricultural Advisory Officer, Australian Fertilizers Ltd., Mr. W. M. Willoughby, Principal Research Officer, Division of Plant Industry, C.S.I.R.O., and Dr. M. C. Franklin, Wm. McIlraith Fellow in Animal Husbandry. A review of the subject matter of the symposium will be published in the March issue of this Journal.

The Branch has appointed Mr. W. F. Ritchie as part-time journalist for the year 1957-58. Mr. Ritchie is a member of the N.S.W. Branch who has had considerable experience in journalism and press-publicity.

At the request of Council, the N.S.W. Branch is arranging the production of a booklet to inform employers and prospective employers of the scope of work in which agricultural scientists may be engaged.

Victoria

The Refresher School organised by the Victorian Branch was held at Burnley Gardens from 2nd-5th September. Reference is made to the School elsewhere in the Journal.

At a general meeting on 25th of October, *Professor J. S. Turner*, Professor of Botany at the University of Melbourne spoke to a large gathering on the subject of maintaining vegetation on the mountain catchment areas.

Queensland

At the July Branch Meeting *Mr. R. C. Colbran* of the Department of Agriculture and Stock

spoke on "Plant Nematodes." The subject of Phytonematology is one that has been frequently neglected by agriculturalists in the past and members were interested to hear details of the occurrence and importance of plant nematodes in Australia from an expert in this field of study.

Mr. R. Milford of the C.S.I.R.O., Cooper Laboratory addressed the August meeting on the subject of "The Nutritive Value of Some Sub-Tropical Pasture Species." The speaker drew attention to the lack of information on the feeding values of tropical and sub-tropical pasture plants and discussed the results of his own work with a number of sub-tropical grasses.

The annual public meeting of the Branch was held on September 25th. The speaker, *Mr. A. F. Bell*, Under Secretary of the Department of Agriculture and Stock, discussed "The Past Decade in Agriculture and the Next." The address attracted a good deal of interest and attention both amongst the audience and in the local press. A number of Parliamentarians and representatives of public bodies and commercial enterprises connected with agriculture received invitations and the meeting attracted a large attendance.

On October 24th a joint meeting of the Queensland Branch of the Institute and the Australian Society of Animal Production was held to hear an address by *Mr. T. H. Strong*, Director, Bureau of Agricultural Economics, Canberra, on "Agricultural Economics in Relation to Primary Industry in Australia".

South Australia

In August, *Prof. G. Lawton*, of the Adelaide University's Geography Department, spoke on "Land Use Surveys."

In September, *Mr. R. G. Downes*, deputy chief of the Soil Conservation Authority of Victoria flew to Adelaide to address the Institute. He spoke on "Ecology and the Development of Land Resources" to a large gathering of S.A. members. The Executive Officer, *Mr. Roberts*, attended this meeting, too, and spoke to the branch on "Industries' Aid to the Institute."

In October, *Prof. R. K. Morton* spoke to the Institute for the first time since taking up his appointment as professor of agricultural chemistry at the Waite Institute early this year. He spoke on "Chemistry for Agriculture," outlining how advances in biochemistry could improve agricultural quality and give better control over agricultural production.

Western Australia

August Meeting

The meeting held on August 9th was of the type that caters for all interests. Each of four speakers gave a short talk (10-15 minutes), each talk being followed immediately by 5-10 minutes of questions and discussion.

The subjects and the speakers were:—

1. "Mesquite in the North West"—by *Mr. G. R. W. Meadly*, Officer in Charge, Weeds & Seeds Section, Department of Agriculture.

Well supported with colour slides, this talk gave a clear picture of the extent of this pest in the pastoral areas, the various methods of control, and their effectiveness.

2. "Concerning Lysimeters"—*Mr. F. Roberts.* —a talk, also illustrated with colour slides, which outlined the three main types of lysimeter and their relative advantages, but dealing mainly with the recent installation of lysimeters for the Institute of Agriculture at the University of W.A.

3. "Reproduction in Collembola and Acarina" —*Mr. W. M. H. Wallace*, Senior Research Officer in the Entomology Section, C.S.I.R.O.

With the aid of photographs taken by the speaker, it was possible to discuss some recent observations on the reproduction of these insects.

4. "The English Agricultural Bill of 1957"—*Mr. R. A. Pearse.* Mr. Pearse had just returned from a lengthy visit to England and was able to discuss the various implications of this Bill and, in particular, its likely effect on the farmers.

September Meeting

This meeting, on September 13th was similar to the one held in August, except that in this case the talks were somewhat related. Each of the speakers attended the 7th International Grassland Conference at the Massey Agricultural College, Palmerston North, New Zealand, in November, 1956. Each speaker discussed various aspects of the Congress and the subsequent tours of the New Zealand agricultural areas. Subjects and speakers were:—

1. "The New Zealand Environment"—*Mr. G. H. Burvill*, Chief Plant Research Officer of the Department of Agriculture.

2. "Grassland Research"—*Mr. A. W. Humphries*, Research Officer, C.S.I.R.O.

3. "Fertilizer Investigations"—*Mr. E. N. Fitzpatrick*, Research Officer in the Department of Agriculture.

4. "Pasture Management in New Zealand"—*Mr. F. E. Ryan,* Agrostologist in the Department of Agriculture.

October Meeting

As in past years, the October meeting was held during Show Week and took the form of a social at Shell House, to which members were invited to bring their wives and friends. The evening commenced with a buffet tea, followed by a short programme of films presented by courtesy of the Shell Company of Australia. Supper was then served.

Show Week provides an opportunity for country members of the Institute to meet each other as well as city members. In recent years this annual social meeting has proved very successful and it is hoped that in future all members, especially those stationed in the country centres, will avail themselves of the opportunities provided.

Tasmania

A report by a Salaries Sub-Committee was discussed at a general meeting held on July 19th. A new log of claims has been prepared based on C.S.I.R.O. salaries before and after the Casteau Award. A submission has now been prepared for presentation to the Classification and Appeals Board. (The Tasmanian Branch is very pleased to hear of the new salary ranges achieved by Agricultural Scientists in Victoria as they closely parallel those sought in Tasmania.)

On August 20th a general meeting saw several C.S.I.R.O. films on subjects including mutton birds, spray irrigation and pasture improvement.

A general meeting of the Tasmanian Branch on 27th September was addressed by *Mr. E. J. Cameron,* a prominent pastoralist and a member of the Tasmanian University Council. Mr. Cameron addressed the meeting on the general subject "What does the Farmer Expect from the Agricultural Scientist?"

The main points of Mr. Cameron's address were as follows.

The tremendous developments taking place in agricultural science make it no longer possible for the individual to keep abreast of everything. Thus it is becoming increasingly important to direct knowledge appropriately to the farmer.

Of the three methods of spreading new knowledge he considered the field or extension officer most important and useful. Field days were on the whole unsatisfactory and State Department Journals and "Rural Research in C.S.I.R.O." failed to really reach the farmer. However, there was a considerable lack of appreciation among field officers of the inter-relation of soil, crops, stock and costs in farming activities.

The lack of understanding towards farm operations was the result of poorly designed agricultural courses. No course was of value unless it was designed to correspond to the actual operations on the farm.

There must be sufficient agricultural scientists available to provide adequate services. There is room for free lance or private enterprise extension services just as there is room for private veterinarians. The primary industries would benefit from free lance officers. If farmers paid for these services the services would be more efficient.

There is a need for agricultural scientists to come closer to the farmer. The scientist must measure up to the job before complaining about his salary.

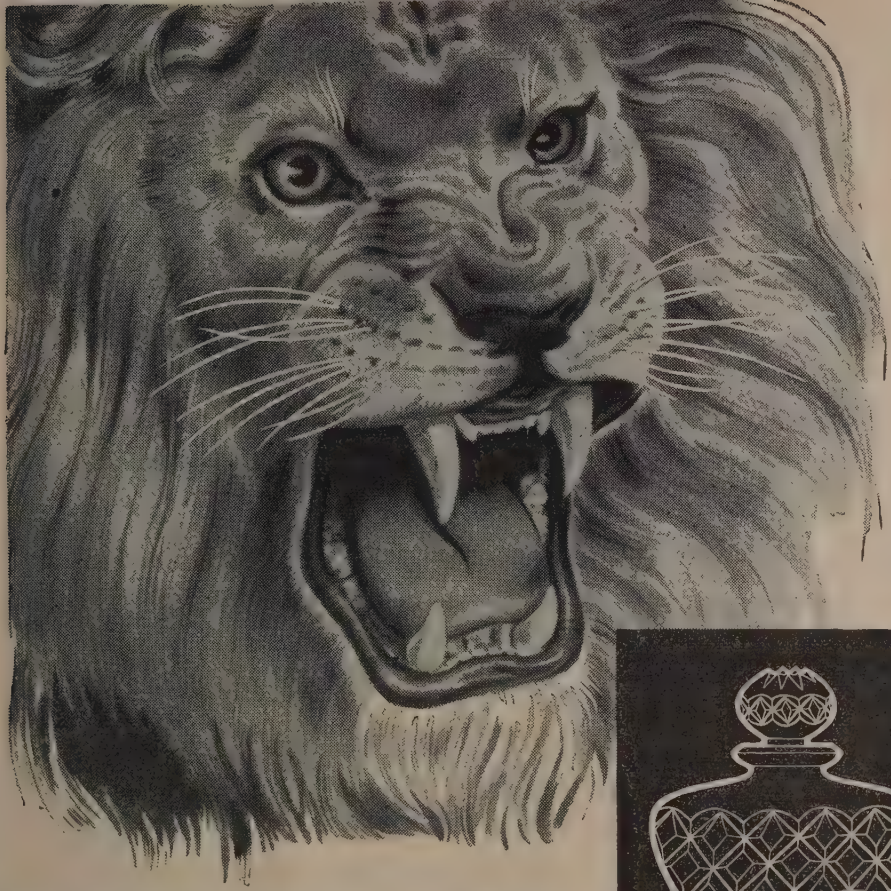
On the 29th October the Branch conducted a symposium on "The Use and Potential of Spray Irrigation in Tasmania".

The meeting was opened by the Branch President, *Mr. I. D. Geard* who introduced *Professor H. C. Foster* as chairman for the proceedings. Papers were given by *Mr. K. D. Nicholls,* regional officer (soils), C.S.I.R.O., Hobart, *Mr. A. W. Knight,* Hydro Electric Commissioner, *Mr. B. D. Millar* and *Dr. J. H. Wilson,* Agronomists, *Mr. H. J. Geddes,* Officer in Charge, McGarvie Smith Husbandry Farm, N.S.W., and *Mr. R. P. Tyson,* District Agricultural Officer.

Of the 136 people who attended nearly half were farmers. Representatives of pastoral and machinery firms, both local and mainland were also present.

It is hoped to publish papers later.

Members of the Branch Committee entertained the speakers and the Executive Officer at dinner following the symposium.



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403/D

APPLICATIONS are invited for a Pineapple Agronomist at a recently established Experiment Station on deep peat soil in Johore, Federation of Malaya. The Agronomist will be required to take charge of the Station and to plan, execute and report experimentation in the cultivation of pineapples on deep peat soils recently cleared of forest. Candidates should have a degree in agriculture or the agricultural sciences and post graduate training in crop agronomy and experimental methods. Experience in tropical crop experimentation will be an advantage. Salary at present exchange rates £3,360 per annum; passage paid for appointee, wife and children on first appointment and on final retirement. Leave with pay 45 days per year accumulatable up to 4 years. Provident Fund deductable at 5% per year—employer contributing 1-10 years' service 10%; 11-20 years' service 15%; and 21 years' + service 20%. House provided on Station in Johore (approx. 50 miles from centre of Singapore) at monthly rent of £8/15/0. Medical and Hospitalisation Fund. Salary liable to Income Tax at present rate approx. £360 p.a. for married man with one child. For further details write: Chief Executive Officer, Malayan Pineapple Industry Board, Government Offices Building, Johore Bahru, Johore, Federation of Malaya.

Closing date for applications, 6th January, 1958.

APPOINTMENT AVAILABLE

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APPOINTMENT OF IRRIGATION AGRONOMIST

Applications are invited for appointment to a position of Irrigation Agronomist at the Regional Pastoral Laboratory at Deniliquin where investigations into problems of irrigated pastures and crops are being conducted.

The appointee will be required to conduct experiments in irrigation agronomy with special reference to efficiency of water use for wool and meat production. This work will be based on current fundamental studies of pasture growth and evapotranspiration.

Applicants should possess a University Degree in Science or Agricultural Science, preferably with an interest in irrigation and soil water plant inter-relationships.

Dependent upon qualifcations and experience, commencing salary will be determined within the salary ranges of Experimental Officer Grade I £953-£1403 or Experimental Officer Grade II £1403-£1673.

The appointment will be conditional on a satisfactory medical examination and the successful applicant will be asked to serve for an initial probationary period of up to twelve months. Upon confirmation of this appointment the appointee will be required to contribute to and will be eligible to receive benefits from, either the Commonwealth Superannuation Fund or the Commonwealth Provident Account.

Applications quoting reference Number 132/69 and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience and war service, if any, accompanied by the names of three referees, should reach the Officer-in-Charge, Regional Pastoral Laboratory, C.S.I.R.O., Box 226, Deniliquin by 6th January, 1958.

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Printed for the Australian Institute of Agricultural Science by Ramsay, Ware Publishing Pty. Ltd. 129 King Street, Melbourne.